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GENERAL DESCRIPTION OF THE MOON.

Part of the introductory chapter from "A Comparison of the Features of the Earth and the Moon," by Prof. N. S. Shaler, Smithsonian Contributions to Knowledge, Vol. XXXIV (No. 1438), 1903. Quarto, pp. 78, with 25 plates.

[CONTINUED FROM THE JANUARY NUMBER.]

Turning now to the shape and structure of the moon's crust, we observe that it differs from that of the earth. Considering first the more general features, we note that there are none of those broad ridges and furrows—the continents and the sea basins. A portion of the surface, mainly in the northern hemisphere, is occupied by wide plains, which in their general shape are more nearly level than any equally extensive areas of the land, or, so far as we know, of the ocean floor of the earth, though they are beset with very many slight irregularities. These areas of rough, dark-hued plains are the seas or maria of selenographers, so termed because of old they were, from their relatively level nature, supposed to be areas of water. These maria occupy about one-third of the visible surface. Their height is somewhat less than that of the crust outside their area. The remaining portion of the moon is extremely rugged. It is evident that the average declivity of the slopes is far greater than on the earth. This is apparent in all the features made visible by the telescope, and it likely extends to others too minute to be seen by the most powerful instruments. Zollner, by a very ingenious computation based on the amount of sunlight reflected, estimates that the average angle of the lunar surface to its horizon is 52 degrees. Though we have no such basis for reckoning the average slope of the lands and sea bottoms of the earth, it is eminently probable that it does not amount to more than a tenth of that declivity.

PLATE IV.

Moon' age, 23 days hours. July 28, 1891. Lick Observatory.

At this stage of the waning moon the most interesting of its fields are no longer visible. There are few that command attention in this plate. It may be noted that the system of light bands and the central patches whence they proceed, that have their center in Kepler, are still very bright. The dark mare-like floor of Grimaldi is visible near the bright margin of the sphere. The observer may obtain something of the impression, such as is afforded by good seeing with a powerful telescope, that the Oceanus Procellarum is a relatively shallow sea by the number of fragments of what seems to have been the more ancient surface that protrude through it.

This difference, as well as many others, is probably due to the lack on the moon of the work of water, which so effectively breaks down the steeps of the earth, tending ever to bring the surface to a uniform level.

The most notable feature on the lunar surface is the existence of exceedingly numerous pits, generally with ring-like walls about them, which slope very steeply to a central cavity and more gently toward the surrounding country. These pits vary greatly in size; the largest are more than a hundred miles in diameter, while the smallest discernible are less than a half mile across. The number increases as the size diminishes; there are many thousands of them, so small that they are revealed only when sought for with the most powerful telescopes and with the best seeing. In all these pits, except those of the smallest size, and possibly in these also, there is within the ring wall, and at a considerable though variable depth below its summit a nearly flat floor, which often has a central pit of small size or in its place a steep rude cone. When this plain is more than 20 miles in diameter, and with increasing numbers as the floor is wider, there are generally other irregularly scattered pits and cones. Thus in the case of Plato, a ring about 60 miles in diameter, there are scores of these lesser pits. On the interior of the ring walls of the pits over 10 miles in diameter there are usually more or less distinct terraces, which suggest, if they do not clearly indicate, that the material now forming the solid floors they inclose was once fluid and stood at greater heights in the pit than at which it became permanently frozen. It is, indeed, tolerably certain that the last movement of this material of the floors was one of interrupted subsidence from an originally greater elevation on the outside of the ring wall, which is commonly of irregular height, with many peaks. There are sometimes tongues or protrusions of the substance which forms the ring, as if it had flowed a short distance and then had cooled with steep slopes.

The foregoing account of the pits on the lunar surface suggests to the reader that these features are volcanoes. That view of their nature was taken by the astronomers who first saw them with the telescope and has been generally held by their successors. That they are in some way, and rather nearly, related to the volcanic vents of the earth appears certain. We have now to note the following peculiar conditions of these pits. First, that they exist in varying proportion, with no evident law of distribu-

tion, all over the visible area of the moon. Next, that in many instances they intersect each other, showing that they were not all formed at the same time, but in succession; that the larger of them are not found on the maria, but on the upland and apparently the older parts of the surface; and that the evidence from the intersections clearly shows that the greater of these structures are prevailingly the elder and that in general the smallest were the latest formed. In other words, whatever was the nature of the action involved in the productions of these curious structures, its energy diminished with time, until in the end it could no longer break the crust.

All over the surface of the moon, outside of the maria, in the regions not occupied by the volcano-like structures, we find an exceedingly irregular surface, consisting usually of rude excrescences with no distinct arrangement, which may attain the height of many thousand feet. These, when large, have been termed mountains, though they are very unlike any on the earth in their lack of the features due to erosion, as well as in the general absence of order in their association. Elevations of this steep, lumpy form are common on all parts of the moon. Outside of the maria they are seen at their best in the regions near the north pole, where a large field thus beset is termed the Alps. From the largest of these elevations a series of like forms can be made of smaller and smaller size until they become too minute to be revealed by the telescope; as they decrease in height they tend to become more regular in shape, very often taking on a dome-like aspect. The only terrestrial elevations at all resembling these lunar reliefs are certain rarely occurring masses of trachytic lava, which appear to have been spewed out through crevices in a semi-fluid state, and to have been so rapidly hardened in cooling that the slopes of the solidified rock remained very steep. The only reliefs on the moon that remind the geologist of true mountains are certain low ridges on the surfaces of the maria.

The surface of the moon exhibits a very great number of fissures or rents which, when widely opened, are termed valleys, and when narrow, rills. Both these names were given because these grooves were supposed to have been the result of erosion due to flowing water. The valleys are frequently broad, in the case of that known as the "Alpine Valley," at certain places several miles in width; they are steep walled, and sometimes a mile

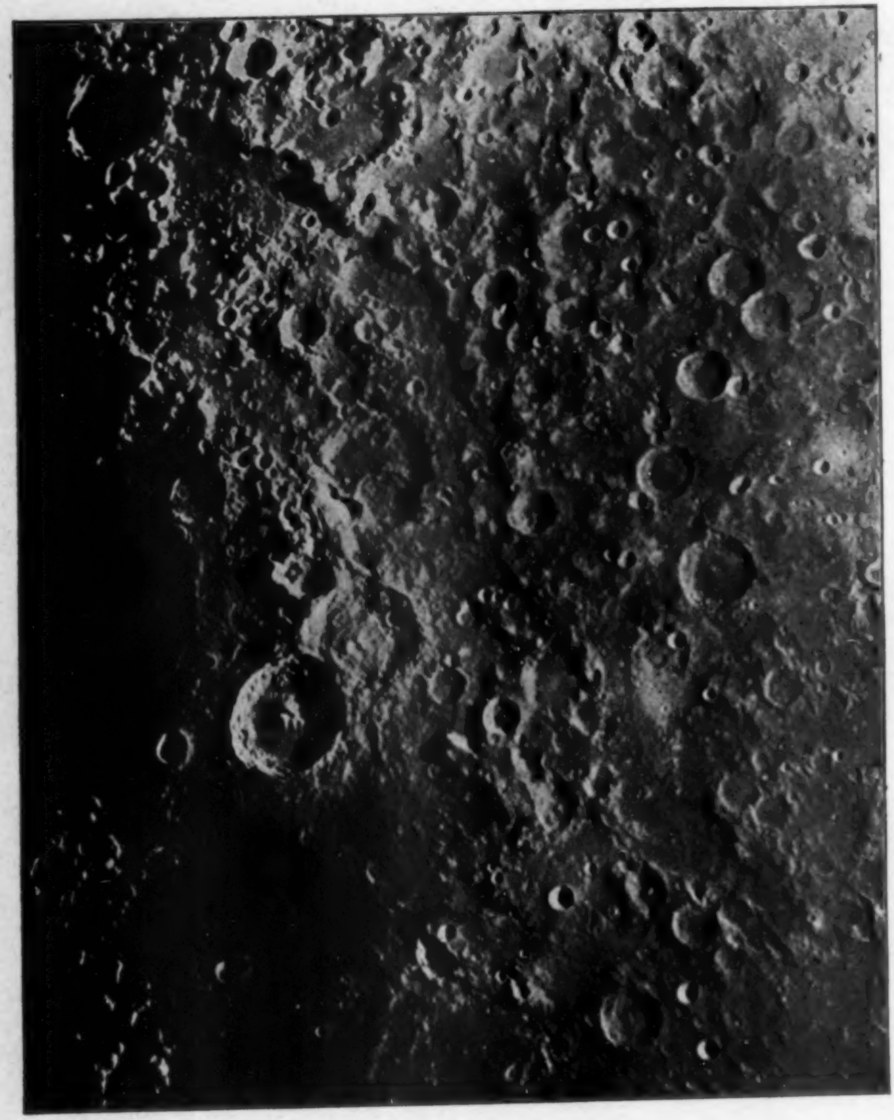

PLATE V.

Photographed by Ritchey with 40-inch telescope, using yellow color screen and isochromatic plate.

This plate shows part of the southwest quarter of the moon's visible surface.

On the lower part of the plate is a portion of the Mare Tranquilitatis; on the middle of the left-hand side a portion of the Mare Nectaris.

The large, deep vulcanoid with the steep, ragged peaks rising from its floor, on the lower left-hand portion of the plate, is Theophilus, one of the nobest structures on the moon. The width of the creater is about 64 miles; the greatest height from the floor to the crest of the wall, 18,000 feet. The central mass, composed of several sharp peaks, rises about 6,000 feet above the lava plain. In the center of these masses there appears to be an obscure crater about half a mile in diameter. The terraces in the inner wall of the cone are indistinctly shown.

Theophilus has partly invaded Cyrillus, the next large vulcanoid on the southeast, an older structure with less steep slopes and a generally ruined appearance. South of Cyrillus, at a distance of half its width, is Catherina. This crater is met by another of half its diameter, which has developed on one side of its floor. From near the southeastern margin of Catherina a beautiful row of small craters extends eastwardly for a distance of over 200 miles to the large vulcanoid Abulfeda. This is perhaps the most noteworthy crater row on the moon.

The long, curved wall extending from Piccolomini, near the upper left-hand corner (the large crater with its floor in the shadow), to the east side of Catherina, is the Altai Mountains. It should be noted that this step-like structure obscurely extends northward to the M. Tranquilitatis, where it forms an iregular ridge-like promontory.

or more in depth; their bottoms, when distinctly visible, are seen to be beset with crater-like pits, and show in no instance a trace of water work, which necessarily excavates smooth descending floors such as we find in terrestrial valleys. The rills are narrow crevices, often so narrow that their bottoms can not be seen; they frequently branch, and in some instances are continued as branching cracks for 100 miles or more. The characteristic rills are far more abundant than the valleys, there being many scores already described; the slighter are evidently the more numerous; a catalogue of those visible in the best telescopes would probably amount to several thousand. (See plates v, vi, vii.)

It is a noteworthy fact that in the case of these rills, and in great measure also in the valleys, the two sides of the fissure correspond so that if brought together the rent would be closed. This indicates that they are essentialy cracks which have opened by their walls drawing apart. Curiously enough, as compared with rents in the earth's crust, there is a little trace of a change of level of the two sides of these rills—only in one instance is there such a displacement well made out, that known as the Straight Wall, where one side of the break is several hundred feet above the other. (See plate vii.)

In the region outside of the maria much of the general surface of the moon between the numerous crater-like openings appears in the best seeing with powerful telescopes to be beset with minute pits, often so close together that their limits are so far confused that it appears as honeycombed, or, rather, as a mass of furnace slag full of holes if greatly magnified, through which the gases developed in melting the mass escaped.

Perhaps the most exceptional feature of the lunar surface, as compared with that of the earth, is found in the numerous systems of radiating light bands, in all about thirty in number, which diverge from patches of the same hue about certain of the crater-like pits. These bands of light-colored material are generally narrow, not more than a few miles in width; they extend for great distances, certain of them being over 1,000 miles in length, one of them attaining to 1,700 miles in linear extent. In one instance at least, in the crater named Saussare, a band which intersects the pit may be seen crossing its floor, and less distinctly, yet clearly enough, it appears on the steep inside walls of the cavity. In no well-observed case do these radiating streaks of light-colored material coincide with the before-men-

tions splits or rifts. Yet the assemblage of facts, though the observations and the theories based upon them are very discrepant, lead us to believe that they are in the nature of stains or sheets of matter on the surface of the sphere, or perhaps in the mass of the crust. At some points the rays of one system cross those of another in a manner that indicates that the one is of later formation than the other. (See plate iii.)

Perhaps the most puzzling feature of the radiating streaks, where everything is perplexing, is found in the way they come into view and disappear in each lunar period. When the surface is illuminated by the very oblique rays of the sun they are quite invisible; as the lunar day advances they become faintly discernible, but are only seen in perfect clearness near the full moon. The reason for this peculiar appearance of these light bands under a high sun has been a matter of much conjecture; it is the subject of discussion in a later chapter of this memoir, where it is shown that inasmuch as these bands appear when the earth light falls upon the moon at a high angle, the effect must be due to the angle of incidence of the rays on the shining surfaces. It should be noted that the light bands in most instances diverge from more or less broad fields of light color about the crater-like pits, fields which have the same habit of glowing under a high illumination; in fact, a large part of the surface of the moon, perhaps, near one-tenth of its visible area, becomes thus relatively brilliant at full moon, though it lacks that quality at the earlier and later stages of the lunar day.

In the above-considered statement concerning the visible phenomena of the moon no account is taken of a great variety of obscure features which, though easily seen with fairly good instruments, have received slight attention from selenographers. As can readily be imagined, observers find it difficult to discern dimly seen features which can not be classed in any group of terrestrial objects. Whosoever will narrowly inspect any part of the lunar surface, noting everything that meets his eye, will find that he observes much that can not be explained by what is seen on the earth. It is evident, indeed, that while in the earlier stages of development this satellite in good part followed the series of changes undergone by its planet there came a stage in which it ceased to continue the process of evolution that the parent body has undergone. The reason for this arrest in development ap-

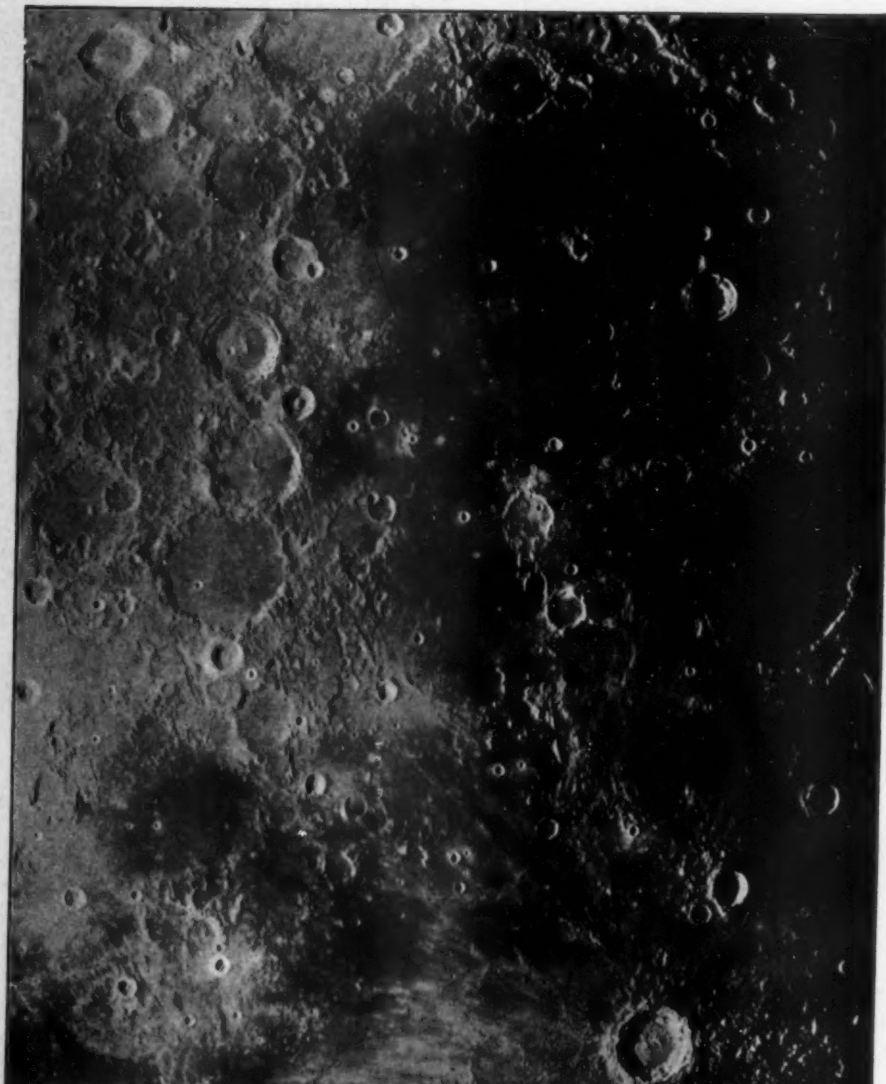

PLATE VI.

Mare Nubium and surroundings. Photographed by Ritchey, November 21, 1901, 7 hours 32 minutes p. m. Exposure, 1 second.

In this plate Copernicus is the large vulcanoid on the lower margin. The large crater near the upper margin, a little to the right of the center, with a cone somewhat to the right of its center and "rill" on its floor, is Pitatus. The three great vulcanoids in a row extending in a north-and-south direction are, in sucession from the lowest toward the upper margin of the plate, Ptolemæus, Alphonsus, and Arzachel. The large, deep crater below and to the right of Pitatus, with a divided central cone, is Bullialdus.

The most notewothy features in this plate are found in the many instances in which the lavas of the maria have partly destroyed the vulcanoids within their fields. In the upper right-hand fourth of the plate there are a dozen or more of these ruined craters, some of them with their walls almost effaced. In this part of the field there are several important rills. Some of these are evidently rows of craterlets in which the adjacent walls of the pits have been broken down so as to form a ragged cleft. A number of these lines of craterlets are traceable on the external slopes of Copernicus. The long, dark line, 65 miles in length, in the upper third of the plate, a little to the left of the center, is the Straight Wall, the most extensive fault known on the moon. The height of its cliff is about 500 feet. The crescent-shaped structure at its southern (upper) end is the remnant of a crater, the remainder of the margin having been destroyed by the lava of the mare. To the right of and nearby the Straight Wall is a rill extending in a slightly curved course for a length of about 40 miles, terminating at either end in a distinct craterlet.

The brightly illuminated part of the field depicted on this plate, that to the left of the center, exhibits many excellent examples of crater valleys, which in their series afford something like a passage from the condition of rills to those of wider depressions.

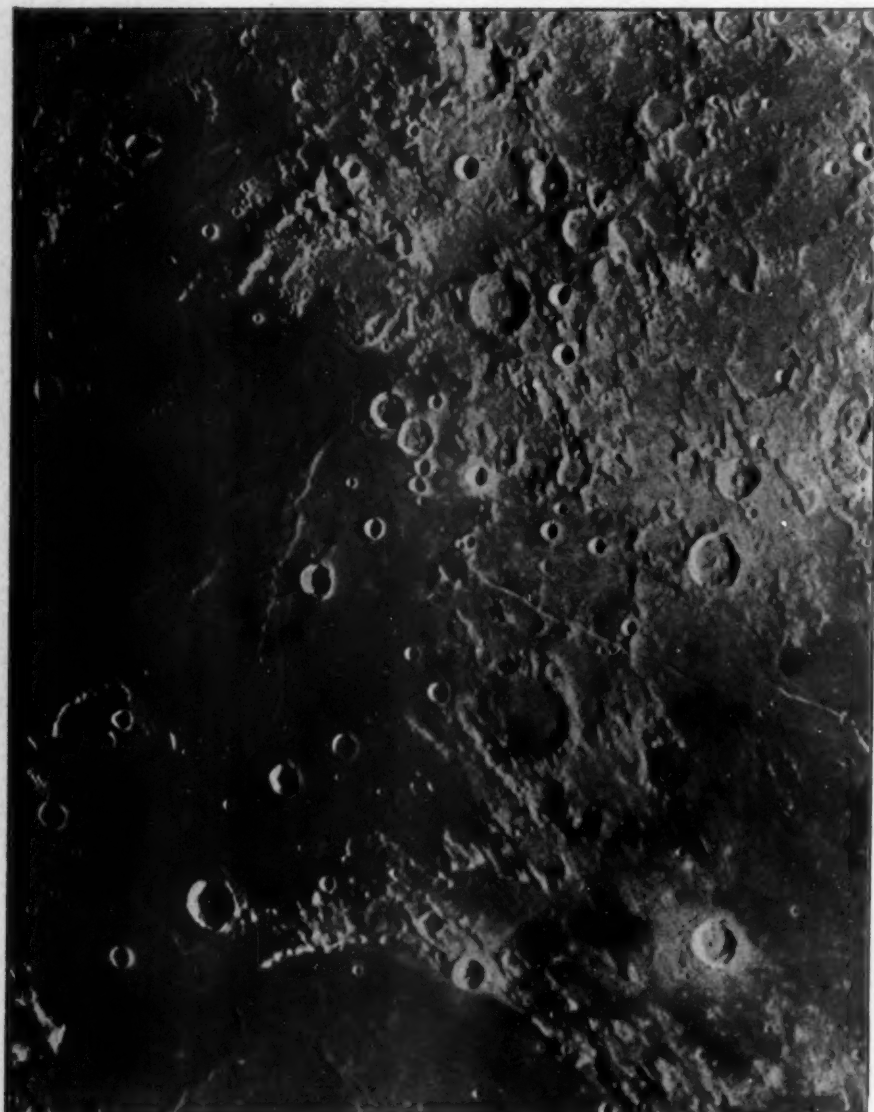

PLATE VII.

Mare Tranquilitatis and surroundings. Photographed by Ritchey, August 3, 1901, 2 hours 30 minutes a. m., central standard time.
Exposure, three-fourths second.

This plate includes nearly the whole of the Mare Tranquilitatis, and on the lower margin, a portion of the M. Serenitatis. The large crater near the strait connecting these maria is Plinius. The highland nearest to it is the promontory of Acherusia. On the southern, or upper, margin the view extends to the flanks of Theophilus.

The most noteworthy features are the mountain ridges on the maria, the manner in which the maria come in contact with the higher ground, the numerous crater valleys, and the great "rills."

It may be noted that ridges on the maria exhibit little trace of corresponding troughs between them, such as are usually found in terrestrial mountain chains.

The contact of the maria with the high ground has evidently resulted in the partial melting of the walls of several vulcanoids. Where these structures are not thus affected they are, apparently, in origin later than the formation of the maria. The crater valleys are abundant on the right-hand or eastern side of the field. Certain of them have been invaded by the lava of the mare.

Some of the greater rills are very well shown. That on the extreme right side is Hyginus. It will be observed that the course of these rills is at high angles to the prevailing direction of the ridges on the mare.

pears to have been the essential if not complete absence of an atmosphere and of water.

The difference in height between the lowest and highest points on the lunar surface is not determined. To the most accented reliefs, those of the higher crater walls, elevations of more than 25,000 feet have been assigned; it is, however, to be noted that all these determinations are made from the length of the shadows cast by the eminences, with no effective means of correcting for certain errors incidental to this method. It may be assumed as tolerably certain that a number of these elevations have their summits at least 20,000 feet above their bases, and that a few are yet higher. We do not know how much lower than the ground about these elevations are the lowest parts of the moon. My own observations incline me to the opinion that the difference may well amount to as much as 10,000 feet, so that the total relief of the moon may amount to somewhere between 30,000 and 40,000 feet. That of the earth from the deepest part of the oceans to the highest mountain summits is probably between 55,000 and 60,000 feet; so that notwithstanding the lack of erosion and sedimentation which in the earth continually tends to diminish the difference between the sea-floor and land areas, the surface of the satellite has a much less range of elevation than the planet. If the forces which have built the mountains and continents of the earth had operated without the erosive action of water, there is little doubt that the difference in height between the highest and lowest parts would now be many times as great as it is on the moon.

METHOD OF DEMONSTRATING "BEATS."

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Adjust an air column in the usual way, i. e. by pouring water into a tall cylindrical jar or graduate so that it will reinforce the sound of a tuning fork. Now hold beside this vibrating fork over the jar, another vibrating fork (preferably an adjustable one) *nearly* in unsion with it. The beats will ring out very clearly. With an adjustable fork the beats may be made many or few.

TROPICAL FRUITS.

By Mel T. Cook,

Chief of the Department of Vegetable Pathology of the Cuban Agricultural Experiment Station.

VIII.—Sapotaceae.

The family of the Sapotaceae contains many interesting tropical plants, not a few of which produce very valuable fruits. It is this particular class of fruits that I wish to call your attention to in this article.

LUCUMA MAMMOSA GAETRU, THE SAPOTE.

The first and most conspicuous is *Lucuma mammosa* Gaetru, which is commonly known as the "sapote" or "mamey sapote." In the western part of Cuba it is known as the "mamey colorado," while in the eastern part it is known as sapote or mamey sapote. I am told that in other parts of the West Indies, Mexico, Central and South America it is known as the sapote. It should not be confused with the *Mammula Americana* of the

family *Guttiferae* (*Clusiceae*), which is the true mamey, but frequently spoken of in Cuba as the "mamey Santo Domingo."

The *L. mammosa* is quite a large tree, with coarse leaves 6 or 8 inches in length and 2 or 3 inches wide. The flowers are small, cream colored and attached to the stems in great numbers. The fruit is at first five carpellate, but as it approaches maturity all but one or possibly two of the seeds become abortive. The mature fruit is more or less oblong, four to six inches in length, with a thick, russet skin and a dark red, rich, sweet flesh. It is used very extensively throughout the island of Cuba.

The *Lucuma nervosa,* or "Canestel", is a much smaller tree, which produces a fruit about one-half the size of the preceding, yellow in color, with smooth skin, two to five well developed seeds, and a rich, dry, yellow, fine flavored flesh. It tastes very much like a sweet, well-baked sweet potato.

The *Achras sapota* is another tropical fruit which is common throughout the tropics of America, and is usually known by the common name of "nisepero", but sometimes incorrectly as sapote. The tree is quite large and the fruit is about two inches in diameter, with brownish skin and four or five small, black seeds. When ripe it has a very sweet flavor.

The *Chrysophyllum cainito* Linn is one of the most beautiful trees of this group of plants. The foliage is very thick and the upper surface is a rich, bright red, while the color of the lower surface varies in the different varieties from a silvery gray to golden and dark brown russet. The movement of the foliage, showing alternately the colors of the upper and lower surfaces of the leaves, gives a most beautiful effect. The fruit is almost spherical, two to four inches in diameter, smooth skin and varying in color in the different varieties from green to dark purple. It has a very sweet taste, and is common on the local markets.

All these fruits are subject to great variations and, therefore, give excellent opportunities for improvement. At the present time, many of them grow wild and no effort is made to select and improve the most promising varieties. However, in time they must certainly find places on our northern markets.

LOGARITHMS IN THE FIRST YEAR OF THE SECONDARY SCHOOL. (II.)

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[CONTINUED FROM THE NOVEMBER NUMBER]

I.—PREPARATORY WORK.

The ideas "factor," "power," "root," and "exponent" are supposed to be working possessions of the class. If they are not clear and usable the class must be taught them, and that, too, whether or not logarithms are to be studied. The usual haziness of first year high school pupils on these notions is both deplorable and unnecessary. The high school teacher must remember that the only remedy for haziness is to clear it up no matter how far back and deep downwards he may have to reach.

Express 100 as *factors in* 10; thus, $100=10\times10$. Express 1,000 similarly; 10,000; 100,000.

Express 100, 1,000, 10,000 and 100,000 as *powers of* 10; thus, $100=10^2$, etc.

Arrange* what has been done thus:

The Number.	Expressed as factors.	Expressed as powers.
100	10 x 10	10^2
1000	10 x 10 x 10	10^3
10000	10 x 10 x 10 x 10	10^4
100000	10 x 10 x 10 x 10 x 10	10^5

What does the small figure, placed to the right and above the 10's in the last column express?

Note—Here test for ideas of exponent and clear it up by numerous illustrations and uses, such as 2^2, 2^3, 2^4, 3^2, 3^3, 4^2, 4^3, 5^3, a^2, a^3, x^4, etc. Give exercises to the class.

Definition—The number (exponent) which expresses how many times 10 must be used *as a factor* to give a certain number is called the *logarithm* of the latter number. Thus, in $1000=10^3$, the 3 is the logarithm of 1000. Give other examples from the foregoing table. Give the logarithm of 1000000; of 1 with 7 zeros following; of 1 with 12 zeros following, etc.

*Much stress is laid in this article on a lucid arrangement of results. This is in conformity with the law that "formal arrangement is in an important sense concreted logic."

Arrange now the following table:

The Number.		Equivalent power.	Logarithm
100	=	10^2	2
1000	=	10^3	3
10000	=	10^4	4
100000	=	10^5	5

Starting with the 4th number of column 1, how may the 3rd number be obtained from it? the 1st from the 2nd? What number following *the same law* could be added above 100 in column 1? Write it in its proper place. What second number in column 1 could be added above the 10, by *following the same law?* Write it in column 1 also.

State in words the law of numbers of column 1.

Law stated—Any number of column 1 may be obtained from the number next below it by dividing the number next below by 10.

State the same law using the word "multiplying" instead of "dividing," making such other changes in the wording as are necessary.

Starting with the last number of column 3, how is the next to the last gotten from it? the 2nd from the 3rd? the 1st from the 2nd?

Add another number above the 2 *following the law* of the numbers of column 3. Add a second number above this "1."

State the law by which each number of column 3 is obtained from the number next beolw it, from the number next above it.

What then is the logarithm of 10? of 1?

Now arrange what has been found thus:

Number.		Power.	Logarithm.
1	=	10^0	0
10	=	10^1	1
100	=	10^2	2
1000	=	10^3	3
10000	=	10^4	4
100000	=	10^5	5

If a number lies between 10 and 100, between what two numbers must its *logarithm* lie? between 1 and 10? 100 and 1000? 1000 and 10000?

What kind of numbers lie between 0 and 1? *Ans.* Fractions less than 1, or proper fractions; between 1 and 2? between 2 and 3? 3 and 4? 4 and 5? Give examples of each kind.

What kind of numbers lie between 1 and 10? 10 and 100? 100 and 1000? 1000 and 10000? Give examples of each kind.

The logarithm of a certain number is 1.684, between what two numbers of column 1 of the table does the number lie?

State between what two numbers of column 1 do numbers having the following logarithms lie:

(1) 2.672? (2) .486? (3) 3.125? (4) 4.061? (5) .186? (6) .006?

Between what two numbers of column 3 must the *logarithms* of the following numbers lie:

(1) 18? (2) 7.84? (3) 25.74? (4) 3.62? (4) 268.7? (5) 1286? (6) 68491?

By this time, or before, some pupil will ask how the logarithms of numbers that are not exact powers of 10 are obtained. If so, for this boy at least, the psychological moment has arrived and the question may be answered with sufficient fulness for the present purpose by the work which follows.

II. LOGARITHMS OF NUMBERS THAT ARE NOT EXACT POWERS OF 10.

How may the next to the last number (the 4) of column 3 of the last table above be found from the last (the 5)? How may the next preceding (i. e., the 3) be found from the next to the last (the 4)? How may each number of column 3 be found from the number next below it? from the number next above it? What, then, is the law of the numbers of column 3? Answer: *Each number of column 3 may be obtained by adding a constant number* (i. e., 1) *to the number next above it.*

State the same law using the word "subtracting" for "adding," making other necessary changes in the wording.

How then might another number be put in between each pair of numbers of column 3 *following a similar law?* Answer: By adding .5 to each number of column 3 excepting the last. We should thus obtain: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5. In a similar way, we could obtain, by putting other numbers between these: 0, .25, .50, .75, 1, 1.25, 1.50, 1.75, 2, 2.25, 2.50, 2.75, 3, 3.25, 3.50, 3.75, 4, 4.25, 4.50, 4.75, 5.

Let us now see whether we may insert other numbers between those of column 1 in accordance with the law of the numbers already in column 1, with the aid of a factor *different from 10.* To this end let us learn and write down the law of the numbers

already in column 1. How may each number of the column be obtained from the number next below it? next above it?

What is the law of the numbers of column 1? Answer: *Each may be obtained by multiplying the one next above it by a certain number* (i. e., 10), *or by dividing the number next below it is by this same number* (10).

For the new series of numbers we wish to obtain by putting other numbers between those of column 1, let the multiplier (or divisor) be x. For the number between 10 and 100 we should have $10x$, and multiplying this $10x$ again by x, the product must then be 100 (why?), or we shall have:—

$$10x^2=100, \text{ where } x^2=10 \text{ (why?)}.$$

Extracting the square root of 10, we find $x=3.1623$.

We now have the new series:—1, 3.16, 10, 31.62, 100, 316.23, 1000, 3162.3, 10000.

How are 31.62; 316.23, and 3162.3 found?

We may again fit numbers between these by taking our multiplier y and noticing that between, say, 10 and 31.62 we should have $10y$ and also that $10y^2=31.62$, or $y^2=3.1623$ (why?); whence, extracting the square root of 3.1623, we find $y=1.7785$. Why is the square root extracted?

We now have the series:—1, 1.78, 3.16, 5.62, 10, 17.78, 31.62, 56.23, 100, 177.85, 316.23, 562.34, 1000, 1778.50, 3162.30, 5623.40, 10000.

How are 5.62; 17.78; 56.28; 177.85, etc., found?

Arranging these numbers in a table, with a third column to show their meanings, we have:—

Numbers.	Logarithms.	Meanings.	Numbers.	Logarithms.	Meanings.
1.00	0.00	$1.00=10^{0}$	177.85	2.25	$177.85=10^{2\ 25}$
1.78	.25	$1.78=10^{25}$	316.23	2.50	$316.23=10^{2\ 50}$
3.16	.50	$3.16=10^{50}$	562.34	2.75	$562.34=10^{2\ 75}$
5.62	.75	$5.62=10^{75}$	1000.00	3.00	$1000.00=10^{3}$
10.00	1.00	$10.00=10^{1}$	1778.50	3.25	$1778.50=10^{3\ 25}$
17.78	1.25	$17.78=10^{1\ 25}$	3162.30	3.50	$3162.20=10^{3\ 50}$
31.62	1.50	$31.62=10^{1\ 50}$	5623.40	3.75	$5623.40=10^{3\ 75}$
56.23	1.75	$56.23=10^{1\ 75}$	10000.00	4.00	$10000.00=10^{4}$
100.00	2.00	$100.00=10^{2}$			

Evidently other numbers might be inserted in columns 1 and 2 and the table extended indefinitely. Such extensions have been made by computers, and the numbers together with their logarithms have been arranged in tables convenient for use. The pupil will readily see how this table could be made and extended either downward, or by the insertion of other numbers between those given in the table.

Number.	Logarithm.	Number.	Logarithm.
1.00000	.00000	5.62340	.75000
1.07461	.03125	6.04296	.78125
1.15478	.06250	6.49382	.81250
1.24094	.09375	6.97830	.84375
1.33352	.12500	7.49894	.87500
1.43302	.15625	8.05842	.90625
1.53993	.18750	8.65964	.93750
1.65482	.21875	9.30572	.96875
1.77828	.25000	10.00000	1.00000
1.91205	.28125	10.74610	1.03125
2.05352	.31250	11.54780	1.06250
2.20673	.34375	12.40940	1.09375
2.37137	.37500	13.33520	1.12500
2.54830	.40625	14.33020	1 15625
2.73842	.43750	15.39930	1.18750
2.94263	.46875	16.54820	1.21875
3.16229	.50000	17.78280	1.25000
3.39821	.53125	19.12050	1.28125
3.65174	.56250	20.53520	1.31250
3.92419	.59375	22.06730	1.34375
4.21695	.62500	23.71370	1.37500
4.53158	.65625	25.48300	1.40625
4.86968	.68750	27.38420	1.43750
5.23299	.71875	29.42630	1.46875

The following table (TABLE II.) contains the fractional parts (called *mantissas*) of the logarithms to three places of decimals of the numbers from 10—99.5, the numbers varying by .5, thus: 10; 10.5; 11; 11.5; 12; 12.5, etc., to 99.5.

No.	0	.5	No.	0	.5
10	000	021	55	740	744
11	041	061	56	748	752
12	079	097	57	756	760
13	114	130	58	763	767
14	146	161	59	771	774
15	176	190	60	778	782
16	204	218	61	785	790
17	230	243	62	792	796
18	255	267	63	799	803
19	279	290	64	806	810
20	301	312	65	813	816
21	322	332	66	819	823
22	342	352	67	826	829
23	362	371	68	832	836
24	380	389	69	839	842
25	398	406	70	845	848
26	415	432	71	851	854
27	431	439	72	857	860
28	447	455	73	863	866
29	462	470	74	869	872
30	477	484	75	875	878
31	491	498	76	881	884
32	505	512	77	886	889
33	518	525	78	892	895
34	532	538	79	898	900
35	554	550	80	903	906
36	556	562	81	908	911
37	568	574	82	914	916
38	580	586	83	919	922
39	591	597	84	924	927
40	602	608	85	929	932
41	613	618	86	934	937
42	623	628	87	940	942
43	634	639	88	944	947
44	644	648	89	949	952
45	653	658	90	954	957
46	663	668	91	959	961
47	672	677	92	964	966
48	681	686	93	968	971
49	690	695	94	973	975
50	699	703	95	978	980
51	708	712	96	982	984
52	716	720	97	987	989
53	724	728	98	991	993
54	732	736	99	996	998

AIMS IN TEACHING ALGEBRA.*

BY H. E. SLAUGHT,

The University of Chicago.

However great your disappointment may be in not hearing Professor Aley this morning, please remember that mine is still greater, and let me have your sympathy in my difficult and embarrassing task of speaking, almost impromptu, upon what was to have been the subject of his address.

In considering the aims which should inspire and control the teacher of Algebra, the following seem to be of prime importance:

(1) *To keep in close touch with Arithmetic.*

Algebra should take its root in arithmetic and arithmetic should find its fruit in algebra; otherwise the study of algebra to the beginner is a confused juggling with symbols. Separation of the two is absolutely fatal, though many teachers and text-books indirectly contribute to this separation by calling 3, 5, 8+7 etc., *numbers* and a, b, x+y etc., *quantities*, as for instance—in solving an equation like 6x—20=x, to have the pupil say: "Subtract the *quantity* x from both sides," just as if x were something belonging to a different realm from the *number* 20 which is to be added to both sides. The pupil should be led to realize at the outset that algebra deals with *numbers* and *nothing but numbers*. and that the operations of algebra are precisely those of arithmetic and none other; that while the number field is enlarged by the introduction of negative numbers and consequently the scope of the operations is broadened, yet the representation of numbers by letters contributes to neither of these results, but only serves to represent these extensions to the eye and mind.

Further separation of algebra and arithmetic arises from the selection of so few problems from the practical field of arithmetic. Much time is spent in fictitious problems concerning cisterns and pipes, hounds and deer, John's money and Henry's marbles, etc., etc.—to the neglect of live and actual examples in interest, percentage, taxes, commission, etc.—in all of which, and many more, algebra may be made a veritable light in the darkness to the pupil who has for years poured over the rules in arithmetic possibly to his final and utter confusion.

*Owing to the enforced absence of Professer Aley. Professor Slaught responded to an over-night call of the committee by presenting the following paper on the topic as originally assigned —EDITOR.

It should be said that the mingling of the roots of algebra in the soil of arithmetic should begin in the eighth grade at latest, but if this has not been done at all, or has been poorly done, then, to change the figure, is the responsibility of the high school teacher all the more pressing to see that the pupil constantly holds fast to the *shore line* of arithmetic while he ventures out upon the sea of algebra, so beset with the hidden rocks of abstract difficulties and so befogged with the mists of uncertainty as to the port of destination.

(2) *To make frequent connection with constructional geometry.*

Most of us will agree that geometry is, or should be made, an easier subject for beginners than algebra. It is more tangible, more concrete, more interesting, and hence should hold a place along side of, if not prior to, formal algebra. But, as such is not the case in our established curricula in this country, the only alternative is to introduce into the algebra as much constructional geometry as possible by way of illustration of algebraic formulas and applications to practical problems. For example we may suggest the geometric representation of the square of the sum and the square of the difference of two numbers and the product of the sum and difference of two numbers, and problems involving mensuration of geometric figures, especially those whose properties can be discovered by experiment and construction.

To be sure, the teacher is greatly prescribed and limited in such applications in the first year of our present curriculum when the pupils have had no formal work in geometry, but in the third year work in algebra, the geometery should play an important part in giving concreteness to all the work. Miss Sykes showed in her paper yesterday numerous kinds of such material and many more close and practical ties are sure to be found between algebra and geometry by the teacher who earnestly seeks to throw light upon the algebra from every possible source.

Not the least important of these geometric helps is the graphic representation in work in simultaneous equations, both linear and quadratic. This point is now pretty well established, so that almost every new text in algebra contains some work in this line, either in the body of the book or in the appendix. The danger, however, is that these things will be looked at for a lesson or two and then dropped, whereas the graphic method and the geometric point of view should be always at hand and in use to clear

up difficult problems, dispel abstract difficulties and lend interest in general to the subject of algebra.

(3) *To make use of every possible device for anchoring algebra to the concrete.*

Not only in geometry but also in mechanics and physics can algebra find a rich source of material. Mr. Bass demonstrated in his report yesterday how profitable this union with physics can be made and Miss Long has been giving object lessons in the same line for several years.

But here, again, the present arrangement of our curricula is a barrier in the way of progress or of general adoption of such a plan. There can be little question but that such a combination would react favorably upon both the physics and the algebra, and yet, the possibility of the adoption of such an arrangement in our high school curricula in general is very remote. Not even in Prussia, if my observations were correct, where the correlation of arithmetic, algebra, geometry and trigonometry has been most effectually carried out, do they attempt, to any extent, to include the physics, but leave that, as we do, for later study by itself. Much, however, can be borrowed from the realm of mechanics and physics to enrich the work in algebra even as it now stands in the curriculum. The principles of equations and the operations with negative numbers may be made concrete by means of mechanical devices, either home-made or bought in the market, such as Donecker's Algebraic Equation Balance. The simpler principles of levers, friction and some others may be studied far enough with home-made material to show how the (*equation*) is used to express a (*law*)—thus revealing to the student that it is not a dead and uninteresting thing without vital connections with the universe outside of the algebra text-book. Of course the algebra teacher cannot, under present conditions, give a course in physics and should not try to, but he can levy tribute upon a few of the more open laws of nature and turn the proceeds to the enrichment of the work in algebra. Let it be said that the teacher of algebra, who besides his pure mathematical equipment, has also a strong working knowledge of physics, should show a decided advantage in dealing successfully with an algebra class over the teacher who has not, for he will be alert to seize the slightest opportunity for relieving the tension in abstract and difficult situations by an il-

lustration or happy turn, even when no formal introduction of physical phenomena is made.

(4) *To strive always for the best adjustment of emphasis upon essentials and non-essentials.*

We, doubtless, all agree that there are some non-essentials in the courses in algebra usually given in the high schools, but we should greatly disagree as to just what these are, and probably they would indeed be different for different teachers, owing to the fact that some teachers have the power to vitalize any given subject and make its study of concrete value while others would fail to do so. As was suggested in one of the papers yesterday it would probably be safer for some teachers to follow the textbook implicitly rather than attempt omission or re-arrangement of matter, and probably no considerable list of topics could be made which would be best for general omission from the work of the first year in algebra, unless highest common factors and least common multiples by the division process, complicated complex fractions, and complicated forms of radicals and exponents might form the nucleus of such a list.

But I have reference to the misplacement of emphasis in other and more insidious ways. For example, the teacher who insists upon conducting a recitation always according to a certain form is emphasizing *routine* to such an extent that a revulsion of feeling is sure to follow and detract from the effectiveness of the work. To illustrate, a teacher may invariably send as many as possible to the board to solve problems and then call upon the class to attend while each one "explains" his work, that is, simply *reads* what he has *written*—line after line, equation after equation, till finally the answer is reached. Such a process can add nothing to the knowledge of the pupil reciting save in the exceptional case of error in the work; it cannot aid the teacher greatly in determining efficiency; it is almost an insult to those of the class who are close enough to the board to read for themselves what is being read for them; and it is absolutely useless for those who cannot see the board.

Again a teacher may habitually call upon individuals for long and prosy repetition of things quite obvious to all or most of the class while really weighty matters and difficult points go over for want of time, thus not only missing the chief point for which the recitation is held, but actually contributing to the dulling of interest on the part of the class,

The teaching of algebra, as of all other subjects, demands daily study by the teacher as to the points in that particular lesson which need the emphasis, and those which are, for the day, non-essential or of minor importance; and having thus chosen the point of application for the day's energy, it is imperative that varying methods of attack be adopted from day to day, so that by variety of process, the enthusiasm and interest may never grow dull.

(5) *To seek educational and cultural values as well as mere mathematical efficiency.*

What shall be done in lieu of the so-called class "explanation" above referred to? Use the situation to develop mental control and thinking power on the part of the one reciting, and mental alertness and critical ability on the part of the class. How? First, by insisting that an explanation demands not a prosy repetition of the various operations which have been performed but rather in assigning the reasons for the steps taken and showing why this particular method of solution was adopted. For example, in the case of a problem, the explanation should dwell upon the deduction of the equation or equations from the conditions given and the general method used in solving the equations rather than upon the mere steps in the mechanical solution. And, secondly, every explanation should be followed by an opportunity for class criticism and a call for volunteers to state or solve the problem in other ways, thus bringing out, often to the surprise of the teacher, many varied points of view and forms of solution which serve both to throw light upon the problem and, best of all, to elicit individual activity and arouse an enthusiasm which can be gotten in no other way. Encouragement should always be accorded the pupil who proposes an alternative form of solution, even though it be long and clumsy, for it is the best solution for that individual, since it is his own thinking. Later when numerous forms of solutions are proposed, the judgment of the class may be developed by choosing that solution which is the most direct and clear cut. Such experience in the class room brings forth the glow of enthusiasm and begets the exultation of individual discovery and accomplishment.

The power to reason, to weigh evidence, to compare processes, to surmount difficulties, to control ones mental power—these and many more educational values should be the gradual and continual product of class work in algebra, and the teacher's aim should be strongly in the direction of these results.

In saying this, however, one does not need to argue for the study of algebra on *account* of its cultural value, but it does imply that the true teacher will find opportunity in whatever he is teaching, and whatever the main purpose, to bring out its possibilities along purely cultural lines.

(6) *To maintain by all worthy means the interest of the pupils at a high pitch.*

Interest here referred to does not mean mere curiosity such as is excited by puzzle solving; it is not a state of giggling expectancy on the part of the pupils whose attention is constantly distracted by flippant and amusing remarks by the teacher, but it is an interest born of intelligent insight and nourished by a keen knowledge of the relation of things, an interest which delights in doing things whose meaning is understood and whose worth is believed in by reason of actual experience.

The realization of the above aims by the teacher will contribute to such an interest on the part of the pupils, and when once it is aroused nothing can restrain the possessor of it from aggressive progress. Should it not be the highest aim of the teacher to arouse, to stimulate, to interest; and in order to do this effectively in the teaching of algebra, should not these contributory aims be held steadily in the foreground:

To keep in constant touch with arithmetic.

To make continual connection with constructional geometry.

To make use of every practical device for anchoring algebra to the concrete.

To strive always for the best adjustment of emphasis upon essentials and non-essentials.

To seek educational and cultural values as well as mere mathematical efficiency.

NEW THEORIES OF MATTER IN RELATION TO CHEMICAL AND PHYSICAL THEORY.*

BY PROFESSOR CHARLES T. KNIPP,
University of Illinois.

The sciences of chemistry and physics form most fruitful fields for scientific investigation, and we may be safe in saying that the spirit of activity in research that seems to pervade the world at the present day is nowhere more active than in the present earnest investigation both theoretical and experimental as to the ultimate nature of matter. We are living in an age of investigation, an age that is contributing to the world's fund of scientific knowledge as no other age or period before has. Ours is an intensely intensive age, and consequently much will be accomplished—the world expects great things—our responsibility is indeed very great.

In such an active age we naturally expect that old theories will be shaken, and often cast aside. This is the history of science, and why should it not be so? As our knowledge of the constitution and harmony of things advances, as the result of theory and experiment, our first formulated theories and definitions are proven to be inadequate, we should, in keeping with the true scientific spirit, modify them, or, if need be, cast them wholly aside. The history of physics and chemistry, especially the former, is full of instances where a theory is for a time regarded as final on account of its seeming completeness in accounting for all phenomena only later to give way to something entirely different.

In the midst of the present day discoveries in science and the consequent shakening of older theories one of the entities—matter, ether, motion—remains intact and unthreatened, i. e., the luminiferous ether. The conception of a pervading medium is not new. Even the ancients found it necessary to account for the phenomena that came to their attention. Their medium had few properties in common with the medium as postulated at present. It was not until the wave theory of light was developed in its partial completeness that the ether as a universal medium began to dawn upon the scientific world and to be accepted as a

*An address delivered before the Chemical and Physical Sections of the Central Association of Science and Mathematics Teachers, December 2, 1905.

reality. The ether of that day was designed to account for the propagation of light through interstellar space in the form of waves. The development of the modern idea of the ether forms a very interesting chapter in the history of physics. The early tendency was to assume a distinct medium for each phenomenon in order to account for such effects in light as chemical, thermal, phosphorescence, etc. It soon became evident that to account for other forms of radiation, such as electric and magnetic, a new ether or ethers must be postulated. This naturally led to great confusion, and tended to check scientific inquiry. A specific type of ether for each particular phenomenon to be explained in itself would be sufficient cause to doubt the existence of an inter-planatary medium.

It is the object of science to reduce the number of hypotheses. Here they had the contrary—they were multiplying the ethers and,perhaps, unnecessarily complicating and hopelessly entangling physical and chemical theories. Later the idea of a single medium endowed with specific and unchanging properties began to obtain favor, and no theory in modern times received a stronger impetus than did the single medium theory when Maxwell showed that all the phenomena of light may be expressed in the same terms that express the phenomena of electricity. Hertz's experiments on electromagnetic radiation proved conclusively that light waves and electrical waves are one and the same—the only apparent difference being one of wave length. Thus the unification of optics and electricity reduced the mediums to one, and this was a long step towards the unification and simplification of the elements.

The idea of a single medium, however, was not altogether new. Upon the basis of a single medium such illustrious thinkers as Lord Kelvin and Helmholtz, in addition to assigning it properties varied enough to account for the phenomena of light, put forth the highly instructive and fascinating theory that the ether not only pervades all space and is the medium through which the propagation of energy takes place but that *ether* is *matter itself*. This conception was vividly set forth by assuming the possibility of ether vortices of various shapes, single, linked and interlinked —of sufficiently varied combinations to account for the multitude of substances known to chemistry. It was proven that in a frictionless and perfectly elastic fluid—such as the ether was assumed to be—a vortex ring would continue forever when once

its form and motion were stamped as it were upon it. This highly artificial theory promulgated over fifty years ago but later brought into disrepute because of lack of sufficient evidence, may now, in the light of the achievements of the last decade, prove in part at least to be a by no means impossible theory.

Aside from this as a possible view of matter we find ourselves hopeless in defining matter in itself and by itself. It is sufficient for our purpose at this point to speak of matter as that which occupies space and possesses weight. By this definition we can readily distinguish between that which appeals to our senses as matter and non-matter.

Matter is divisible. According to the old scholastic conception this divisibility could be carried on forever and forever—that in the end you still had left two halves of the original substance. This idea, however, is no longer tenable. We long ere this have had positive proof that it is utterly incapable of explaining the phenomena of the physical world.

There then came the conception of the molecule and atom. The former being the smallest particle of a substance that can exist in a free state and yet retain the identity of the substance, and the latter, the atom, the smallest particle of an element that exists in any molecule. The Daltonian theory of the atom is the doctrine that the atom is indivisible, and that atoms of one type of matter or element are all alike but different in essential and recognisable properties from atoms of any other type. This view held without exception until quite recently, yet in many of the rare earths the differences are so slight that the validity of the law might be questioned.

The number of forms of matter in our world reaches an astonishing total. We naturally expect this when we reflect on the possible number of combinations and permutations that the seventy odd elements known to science allow.

It has long been recognized that governing matter in its multitudinous forms there is one great and fundamental law known as the law of the conservation of matter. Correlated with this and intimately connected is another equally great and fundamental law that governs another of the three entities, namely, the law of the conservation of energy. These two great laws are so fundamental, in their invariability so iron-clad, that to question them seems almost a direct insult to science.

The clue that led to the remarkable results of the past ten years

and which has given us new insight in the constitution of matter was obtained from the study of the electric discharge through gases. The person that has made the greatest contribution to our knowledge of the discharge through high vacua is J. J. Thomson. By employing instruments of the highest precision and methods that are faultless, he has shown that a gas may be rendered conducting to a more or less degree, (1) by heating, (2) when the gas is diffused through an electric field, (3) when subjected to the direct action of X-rays, (4) or to the impact of the cathode rays, and (5) when the gas is placed under the influence of ultra-violet light. The gas is rendered conducting by the above agencies in that it is ionized into component parts carrying positive and negative charges. The positive ions are attracted to one electrode of the vacuum tube and the negative to the other. The ions shot off from the cathode are negatively charged and constitute the cathode rays. Through skill and ingenuity, together with wonderful ability in the application of mathematical analysis, Thomson succeeded in 1897 in measuring the charge that the cathode particle carries. It was shown that this charge is equal to that carried by the hydrogen atom. This together with other data enabled him to determine the mass of the ion. To the astonishment of the scientific world this mass was found to be one thousand times less than the mass of the hydrogen atom—the smallest atom known. This is the first definite experimental evidence that the chemical atom is not the smallest unit of matter as was formerly supposed.

These negatively charged ions or electrons, as they have come to be known, carrying equal charges were all found, as far as experiment reveals, to be apparently identical, for the ratio $\frac{e}{m}$ of the charge of the electron to its mass was in all cases the same. We may conclude from this that electrons are a constituent of all matter. This result strengthened the opinion that all matter in its ultimate nature is identical and is strong evidence in favor of a common origin. However, in the light of recent developments in radio-activity our faith in this principle is shaken, and I may add that also for the same reason our faith in principles older and apparently more firmly established than the unification of matter is equally shaken.

The unification of electrical and light waves marked in a sense the culmination of our knowledge regarding types of radiation

allied to light, which for centuries have been the object of inquiry. In the beginning when men's minds were first attracted seriously to the subject it was thought that all radiation from the sun to our planet or for that matter from the object to the person—visual radiation—was in the form of small corpuscles or pellets shot from the radiating body. The idea of pellets in the day of Newton was the result of a necessity, for, to him, as well as to present day philosophers, action at a distance through space of one body to another is inconceivable. His corpuscular theory in time gave way, so far as light is concerned, to the more satisfactory and elegant view of waves in an all pervading ether, yet it has a remarkable bearing upon the discoveries of the last decade. Ten years agc all the known radiations from the extremely short waves of the ultra-violet through the visible spectrum and infra-red to the extremely long Hertzian waves were satisfactorily accounted for by the postulation of an ether. At the present day we have all these radiations and more. It has been recognized by experiment and theory that the undulatory type of radiation is not the only one existing in Nature. We have learned to recognize a type of radiation wholly different, yet not quite unlike the early conceptions of Newton. Hence to-day the term radiation applies with equal propriety to two distinct and fundamental phenomena, namely, waves through the ether, and corpuscles shot out from an exciting body.

By radio-activity then we mean that property that a substance possesses whereby it is able to cause the radiant expulsion of corpuscles or minute particles of matter, projected through space at an exceedingly high velocity. The discharge in a Crookes tube observed some thirty years ago referred to the above as the cathode rays and was the first example of this class of radiation.

But the first clue to the discovery of radio-activity was given by the discovery of the X-rays in 1896 by Roentgen. It had long been known that when cathode rays fall on the walls of the vacuum tube the glass is rendered fluorescent. Naturally it was thought that this fluorescence was necessary in the production of X-rays, and with this idea it occurred to H. Becquerel to try some salts, such as the salts of uranium, that fluoresce readily when exposed to ultra-violet light, to see whether they would give out X-rays. And indeed, as he expected, the plate was affected. Now the conclusion that this immediately led to, strange as it may seem, was false. We know now that the production of

X-rays has nothing at all in common with the fluorescence observed on the glass walls of the vacuum tube. The X-rays are most actively produced when the cathode rays strike a substance, such as sheet platinum, which does not fluoresce at all. Again, we know that the fluorescence of uranium salts is quite uncomnected with the invisible rays that they emit. And lastly we know definitely that these rays—the rays from uranium—are a different form of radiation than X-rays. It was the action of these rays given off spontaneously by uranium salts that affected the photographic plate of Becquerel.

Thus radio-activity was discovered, and in honor of the discoverer the rays from any radio-active substance are termed Becquerel rays. The properties of the Becquerel rays from uranium are intensely interesting as well as striking. Their action on a photographic plate has been referred to. In several other respects they are also similar to X-rays in that they can not be reflected, refracted or diffracted. A property common to both is their ability to ionize gases. This property is readily studied by means of a delicate electroscope.

Another element that was found to be radio-active is thorium, and as far as experiment is able to tell its activity is approximately the same as that of uranium.

The account of the discovery of other active substances is interesting, and especially interesting is the work of Prof. and Mme. Curie, relative to the discovery, extraction, and later the investigation of the properties, of that most active of all known substances—radium. The work of these two untiring scientists is an example of that indefatigable perseverance that characterizes the truly great investigator, It is through the efforts of such persons as these that rests the solution of this enigma to scientists—the ultimate nature and constitution of matter.

(*To be continued.*)

TO TEACHERS OF PHYSICS.

At the sessions of the Central Association of Science and Mathematics Teachers, and elsewhere, the statement is frequently made by teachers of Physics that the mathematical attainments which pupils bring to physics in the secondary school are as a rule quite inadequate.

The following may be taken as fairly typical:

"This leaves the boy free to make all the mathematical errors of which he is capable; and the number and variety of these which he can put into a simple calculation, especially if it involves a trifle of algebra, is the despair of the teacher,—I cannot say the wonder of the teacher, for the phenomenon, remarkable as it is, soon fails to excite surprise. * * * I find upon inquiry that other teachers, not only in this country, but in England also, report similar weakness in their pupils. Mathematical feebleness and fallibility are the birthright of no small part of every class beginning physics. The only question is, what to do about it."—Hall, Teaching of Physics, New York, 1902, p. 287.

For the teacher of mathematics the question is a serious one and deserves careful attention. I have some theories of my own with respect to the causes of this deficiency, but, believing the views and experience of the many would prove much more illuminating than those of one or a few, I venture to propose the following questions to teachers of physics:

1. Does your experience warrant you in making as strong a statement as that of Professor Hall concerning the mathematical deficiencies of your pupils?

2. Or, on the other hand, do you find that your pupils recall as well as they should the mathematics which they have previously been taught?

3. If not, to what extent and in what respect are they deficient?

4. What do you regard as the causes and what is the remedy of this state of affairs?

5. General remarks.

6. Do you authorize the publication of your statements with your name?

Those who are willing to reply to these questions are re-

quested to send replies at their early convenience to the address below. The replies will be collated and a summary published, together with such general remarks as the character of the replies may elicit, and the citation of particular statements in so far as they throw special light on the questions discussed, but, of course, no names will be published without authorization.

The value of such an inquiry depends on the number of replies received, and it is hoped that a large number will have the goodness to send at least a brief reply. No one should hesitate to reply because he has no decided views or experiences. The proper average will be reached only if these conditions also are duly represented among the replies. J. W. A. YOUNG,

The University of Chicago.

LABELLING PARAFIN BLOCKS.

BY FRED L. HOLTZ,

State Normal School, Mankato, Minn.

The following may be nothing new, nevertheless it is an excellent way to keep a record of the material embedded in paraffin blocks. When much sectioning has to be done and the embedded material accumulates faster than can be sectioned, or it is desired to preserve an unsectioned remainder this method is one that will prevent confusion and waste, resulting from forgetting just what was embedded in the blocks. On a small paper slip write the name and character of preparation, whether stained or injected, and lay this in the surface of the still liquid paraffin with its embedded material and let it solidify with the block. Or melt the slip on with a hot wire after the block has been cooled. In this way there are no troublesome wrappers and the label cannot get off.

A more systematic way would be to keep a memorandum book, numbering each object embedded and writing this number on the label to be embedded in the block.

PRESENT TENDENCIES IN THE TEACHING OF ELEMENTARY PHYSICS. *

BY R. A. MILLIKAN,
University of Chicago.

I regard it as unfortunate that so much of the discussion of what ought to be the aims, the method, and the content of a high school course in physics comes from those who are not themselves in daily contact with high school work—those who in the words of Mr. Gilley, "are sitting coolly in the shade and criticising the work of the toilers in the sun." A few brief hours of actual experience in a secondary school laboratory would prick many a pretty bubble which has been blown, and leave nothing but a little blob of froth upon the pipe rim. Realizing that, with a few notable exceptions, university men have been conspicuous failures in their Quixotic reform excursion into the domain of high school physics, I respond with some hesitation to the editor's request for an article upon this topic; for, perhaps, I, too, shall only add a few more pages of useless, impractical discussion, in spite of the fact that for seventeen years I have been more or less closely associated with high school work. Nevertheless, since, upon various occasions, I have expressed my views in extempore fashion to many of those who read this journal, I confess that I welcome an opportunity to set down my thoughts upon this subject carefully, and in order.

Let me assure you first, however, that I do not come in the spirit of Mahomet, the one and only prophet of a great and new faith, urging all men to join me in a crusade against an order of things which is altogether bad. I am not presumptuous enough to believe that the methods of elementary instruction in physics, which have been slowly evolving in this country during half a century of careful selection of the good and elimination of the bad on the part of thousands of able teachers, have netted a result which is wholly contemptible in comparison with some briliant dream which has come to me over night. I realize fully that secondary school physics was never taught

*This article is the substance of an address delivered in May, 1905, before the Chicago Section of the Central Association of Science and Mathematics Teachers.

so well in this country as it is to-day, and that it is not now taught so well in any other country as it is in the United States. Furthermore, when the young high school boys who are my neighbors tell me that physics is the most popular and interesting study in their whole high school curriculum, and when similar reports come to me from scores of schools which I am brought into contact with in the discharge of my duties as examiner in physics at the University of Chicago, I confess that I listen with some surprise to remarks about the complete inadequacy of existing methods in the teaching of physics, or to laments about the decline in interest in physics in the public schools. I confess that I strongly suspect that such talk arises solely from ignorance as to what existing methods and existing conditions are. Some time ago I received a letter from a man who had made a wonderful discovery. For three hundred years the world had been all wrong in its theory of gravitation, As a matter of fact the earth was a great magnet which held bodies to itself by magnetic force alone. My correspondent had found a way to neutralize this force. He had therefore discovered the secret of flying. He could henceforth control the transportation of the world. Did I not wish to get in with him on the ground floor? He wished to assure me that he was not in any sense a crank; that I might refer to Messrs. Jones, and Smith, and Brown for proof of his entire sanity and standing. And, as a matter of fact, in native endowment this man was probably no more of a crank or fool than you or I. *All that he lacked was a knowledge of the subject up to date.* In Newton's day his suggestion would have been almost as well worth consideration as Newton's own. But between that day and this there have intervened three hundred years of experimentation. It was his ignorance of this which made his proposition foolish.

Now the world is full of this man's pedagogical brethren—men who, as they dream by their firesides, suddenly see visions of great new truths, and start out with them to revolutionize existing things. Nine times out of ten, their truths are either falsehoods, or else they are truths which are new to them, but not to their more experienced and more level-headed fellows who see things in their perspective. With the men who are raising the red flag in physics and calling to revolution, I wish to disclaim all sympathy and all companionship. I have no revolutionary measures to propose. Just as science knows no revolutions,

but only quiet and continuous evolution, so the teaching of science progresses, for the most part, by a process of accretion, not by that of upheaval. I wish to act simply as a chronicler of the main directions in which the present day teaching of elementary physics seems to me to be evolving.

I. The first tendency which I see, and greatly rejoice in, is a *tendency away from the academic, or college preparatory, type of physics, to a physics which exists solely for the sake of meeting, in so far as it is possible to do so in one year's time, the present and the future needs of the pupil with reference to the whole subject of physics,* and that without any reference to the possibility of a college course later on. The tyranny of the university over the high school is gradually coming to an end. Heretofore, college entrance requirements and college entrance examinations have been the most terrifying hobgoblins which have stood in the path of the progress of physics in the public schools. We are school for college; that but five out of a hundred high school just beginning to realize that the high school is not a fitting-pupils ever enter college anyway, and that therefore the sole purpose of a high school course in physics should be *to interest and train the pupil in the observation and interpretation of the great number of physical phenomena which lie about him on every side; which thrust themselves more and more forcibly upon his attention with every new development of our industrial life, and which he needs to know how to interpret, both for the sake of his own happiness and for the sake of his usefulness in the community.* This means that the physics course should become, as indeed it is becoming, more and more *practical,* more and more a study of how physical appliances, be they mechanical, thermal, electrical, acoustical or optical, function, and why they function as they do. It means that it is becoming less and less a study of the bare foundations of physics, less and less a study of the abstractions of dynamics, less and less a drill in the solving of mathematical puzzles, and more and more an intimate contact with real, tangible, concrete things, with levers and pulleys, and windlasses and cranes, with hydraulic presses and elevators, with the various types of water, and steam, and electric, and gas machines, with musical instruments, with telescopes, microscopes, etc. In a word we are learning the wisdom of postponing the minute study of the bricks of which the house is made until after we have gained some notion of what the house itself looks like. And, in

my opinion, whether a boy is going to college or not, this is the only proper way to introduce him to physics. The minute study of foundations is important in its proper place; but its proper place is in the advanced, not in the beginning course. There is no part of physics which can so well be left to the college and engineering school as the discussion of the intricacies of mechanics which are indeed the foundation itself of physics. For the conceptions of mechanics are the most abstract, the most difficult, the most widely removed from immediate experience of any of the conceptions of physics, and yet they are often elaborately and laboriously treated in beginning courses to the exclusion of almost everything else.

II. The second tendency, which I note with great rejoicing, and which is closely connected with the last, is *the tendency to adapt the treatment more and more to the stage of development of the adolescent student,* rather than to cram university methods into high school children. The most common and most serious defect which still exists in many a high school course is that the attempt is made to make it too analytical, too mathematical, too philosophic, too logical, too rigorous, in one word, too old for the child for whom it is intended. Third year high school pupils are at the *observational,* not at the *philosophic* age. The power of abstract reasoning only comes with maturity. Facts must come before philosophy. Facts are, indeed, the basis of all philosophy. No one is in a position to reason out abstract principles until he has accumulated sufficient experimental data to continually call concrete images to his aid. The primary object, therefore, in a first course in physics is to get just as many of these facts, and just as many of these concrete pictures before the student as is possible, and in as simple, and natural and direct a way as possible, even though in the process we may have failed to make all definitions with absolute rigor, or to carry out all syllogisms in the manner prescribed by the rules of mediæval logic.

Let me illustrate by a few concrete examples. Why does a teacher of first year physics ever bewilder his pupils with an attempt at the philosophic definition of such fundamental concepts as mass and force, concepts which to every child are as simple and obvious as sunlight, however far from obvious they may be to the subtler intellect of the philosopher. No teacher ever thinks of befuddling a child with attempts at the rigorous definition of

space or *time*. But mass and force are in precisely the same category. Their rigorous definition requires metaphysical and philosophic distinctions which the high school pupil is not ready for. He wants to know the immediate, not the ultimate, causes of things. If you ask me what I should tell him about such concepts as mass and force, I should say show him simply how in actual life masses are compared, namely, by the balance, and how forces are measured, namely, by the stretches which they will produce in a given spiral spring. When you have done that you have come as near to a definition of these concepts as you want to come in a beginning course. Attempting to get at mass through inertia, or force through Newton's second law, is at this stage simply a source of confusion and a waste of valuable time. It is like feeding beefsteak to a first year infant. It hurts him, not because it is in itself bad, but because his assimilative processes are not yet equal to it.

Again, what is a ray of light? Have your students work with it in the laboratory and discover its laws, but postpone all attempt a rigorous definition until the pupil knows more about light than he does in his first course. Physics, what is it? You will be ready for the definition after you have finished the course. And so on with most of the definitions which used to be found in the first ten pages of many of our texts. The students were not ready for them. They degraded the intelligent study of physics into a process of servile memorizing.

In a word, then, we are coming to develop the subject of elementary physics more and more in the *natural* way—the way in which it normally comes to all of us—and less and less in the strictly *logical* way—the way which might, perhaps, be the normal way in the case of mature students. We are throwing the pupil in among the phenomena of physics and letting him see and obsorb as much of them as he can. We are beginning to give heed to the fact that knowledge does not in general come to youth in the form of syllogisms; that it is the result, the whole thing, the complete phenomenon, which is first presented to him, and which first awakens his interest; that this is the starting point from which he works back to *relations* between phenomena, i. e., to the whys and wherefores of physics. No one would dream of teaching a boy to understand the steam engine by first setting him to studying minutely all the parts of the engine, without reference to their use or their relations to other parts, and after

each part was mastered, having him put them all together and see the engine run. Yet this is precisely what we do when we develop, at the beginning of a course in physics, every one of the involved laws of mechanics which we ever expect to use anywhere in the study of physics. The trouble is that we are teaching physics precisely as we ourselves were taught it in college, forgetting that college methods are wholly unsuitable for the high school.

Does this elimination from the high school courses of university methods mean that the course is becoming any less thorough or any less systematic than it used to be? It means nothing of the kind, although I grant that it may be becoming a little less pretentious. The thoroughness of a course, and, indeed, its disciplinary value, too, is measured, not by the number of problems which are mechanically solved, nor by the number of definitions which are memorized, nor by the number of hours which are spent in grinding out uncomprehended mathematical analyses, *but rather by the interest and enthusiasm which is invoked; by the comprehension which is imparted by the observational and reasoning power which is developed.*

(*To be continued.*)

Researches on radium and Radio-activity.—In a paper read before the Société des Ingénieurs Civils M. Besson explains the method by which M. and Mme. Curie were led to discover new radio-active bodies in the ores of uranium, and reviews the preparation of radium, the composition of the Becquerel rays emitted by radium, and the demonstration of MM. Curie and Dewar that radium is converted into helium; and finds in this decomposition the source of the energy of radium. He holds that the decomposition for bodies of light atomic weight would be general; uranium would be converted into radium, then into helium; thorium would be converted into argon. He states that the ores recently discovered in the Department of Saone-et-Loire are pyromorphites, probably rendered radio-active by emanations proceeding from dissolution in water of the phosphites of uranium found in the same lands. The simplest process for search is that of photographic plates. It is sufficient to pulverize the ore believed to be radioactive, to put it in a cup and leave it for twenty-four hours, well surrounded with black paper. By comparing the marks produced by a small parcel of the uranium metal with those produced by the ore supposed to be radio-active, it is easy to ascertain whether this contains radium or not.—*Scientific American.*

THE WORK OF THE HYDROGRAPHIC OFFICE IN ITS RELATION TO COMMERCE.*

By W. J. Wilson,

United States Hydrographic Office.

The work of the United States Navy is more important in time of peace than in war. The policing of nations is the least of its duties. In reality, it is called upon to keep abreast of the times in all scientific advancements; to develop these numerous phases of science, and adapt them to the commercial needs of the country. To show how intimately this work reaches the nation as a whole, it is only necessary to say—that when two people in Kansas have an argument as to the difference of time in watches, they must get the correct time from the U. S. Navy; so, too, in the courts, very frequently when witnesses differ on the question of time they will appeal to the Hydrographic office for the exact date, hour and minute under discussion.

To find the cause and know in advance the direction and force of the winds, currents, fog belts, icebergs, etc., for the oceans has been a very important task for the Navy Department. It would seem at first glance that to have a trained force of expert men devoting their time compiling data to show us how the winds blow, would seem about as foolish and purposeless a task as could well be devised, and yet millions of dollars of property and lives have been set afloat at the mercy of these winds for hundreds of years, and even on our Great Lakes, previous to 1880, the wind was moving an amount of property daily, and thus performing an amount of work so vast that it would require all the horses of the United States to replace it if we had to depend on equine instead of aerial forces.

The elements of astronomy are taught in our public schools. Probably every one here today can remember studying the names of the constellations, Great Bear, Little Bear, Dog Star, Moons of Jupiter, etc., and about all that most people remember after leaving school is that the names of the stars are inextricably mixed up with Greek Mythology, and that people with a liking for mathematics, and a distaste for natural sleep, spend their nights in looking through great tubes, and making calculations whose fig-

*An address delivered before the Earth Science Section of the Central Association of Science and Mathematics Teachers, December 2, 1905.

ures run into billions and trillions. If asked what relation the science of this star-gazing professor bore to the coast line of the United States, or to the position of the Hawaiian Islands, most people who are ordinarily well educated would say, "none at all." A few, remembering the names of Venus, Jupiter, Sirius and other prominent heavenly bodies, might be willing to admit that there was some relation to the Gregorian calendar; but that the boundary lines of nations and movements of commerce are governed by astronomy will be news to most people; and yet this is strictly true, and furnishes the only reason why the Navy Departments of the world maintain Naval Observatories.

If time permitted I could also instance similar and intimate connections between the scientific investigations of physics, chemistry, dynamics, and various other departments of science, but enough has been said to show that the real work of the Navy consists in labors which have a direct and practical application to the comfort and happiness, as well as the financial wellbeing of every inhabitant of the United States.

It seems peculiarly appropriate in addressing an audience of teachers, to point out and insist upon the practical and commercial application of pure science. I can remember that as a school boy, I wondered long and seriously as to why I should fill my head with the mysterious applications of x plus y, or the properties of the hypotenuse, or what difference it made if Jupiter had four moons or twenty. Had my teacher been able to tell me the practical applications of physics, chemistry, mathematics, and the properties of heat I should need to know in after years, the most disagreeable of my tasks at school would have become the most interesting, and my proficiency would have been correspondingly increased.

Probably every teacher learns early in his or her experience to dread that vexatious word, "Why?" I am meeting with it daily and Professor Wood tells me that it stares the teachers of today in the face with the same persistency as of old. I can remember that when our class found a teacher who could show us "why?" by tracing the application of pure science to the operations of every day life, the dullest and most incomprehensible things contained in the text books were immediately invested with all the interest of a game of "I spy", and the dullest and most unruly pupils were transformed into orderly and attentive leaders of their classes. It is for this reason that I shall attempt to try

and show you a few of the applications of pure science to every day life, in outlining briefly the work of the Hydrographic Office of the U. S. Navy Department, and its relation to commerce.

The Navy Department is organized under the following Bureaus: 1, Yards and Docks; 2, Equipment; 3, Navigation; 4, Ordnance; 5, Construction; 6, Steam Engineering; 7, Supplies and Accounts; 8, Medicine and Surgery.

The Bureau of Equipment, among other duties, has charge of the Hydrographic Office; the collection of foreign surveys; publication and supply of charts; sailing directions and nautical books, and the dissemination of nautical and hydrographic information to the Navy and also to the mercantile marine.

Wherever the flag of our country is seen floating at the peak of a man-of-war, there the work of collecting, compiling and forwarding hydrographic data to the hydrographic office in Washington is going steadily on. Whenever a Naval vessel visits waters not already charted by other nations, special and elaborate surveys are made and issued through the hydrographic office to the world.

The distribution of this information "to the Merchant Marine" has grown practically to mean that it is distributed to the entire commercial world, as the transportation of goods is inseparably connected with all commercial business. The Bureau of Equipment is now engaged in the development of wireless telegraphy, a work which is bound to have immediate and far reaching results on commerce in general.

We mentioned a moment ago that there was a relation between the science of astronomy and the coast line of the United States. It might be of interest to state in detail just what that relation is. In the making of maps and charts, as in everything else, there must be a starting point; that starting point is determined by the observation on fixed stars. It is by the observation of heavenly bodies that we know the distance between the North and South poles of the earth; the diameter and position of the equator; and hence is established our units of measurement; the knot, which is a fraction of a great circle of the earth; the French meter, which is a fraction of the distance of a meridian of the earth. It is one of the beauties of geometry and trigonometry that we can determine the distance between any two points by the calculations of angles and elapsed time, easier, quicker and more exactly than we can do it with a tape measured in meters; thus we

know the distance between the North and South poles, although no one has ever been at either.

As measurement by other units is impossible, the shipmaster must measure his distance traveled by means of his log, and observations of the sun, moon, stars and planets, together with the elapsed time between his previous observations. Consequently it is of great importance that we should know the constantly changing units upon which we must depend for our measurements, and so the star-gazing professor with his billions and trillions is really sitting up nights to perform a very important service for the commercial world.

Time is a measure of the angle assumed by the sun. When it is exactly over the head of a person standing on the equator, it is noon; and it is noon everywhere in a north and south line, passing from the equator to the poles. This imaginary line is called a meridian of longitude, and as there are as many meridians as there are positions of the sun, naturally these meridians are infinite in number. For this reason we must have a starting point adopted by general consent, and that starting point is the meridian of Greenwich. Having thus secured a starting point, we are able to make longitudinal calculations east and west from this base and we can print the various calculations in the Nautical Almanac in such a way that they will generally be understood.

We thus have the poles and the equator as the north and south units, and the meridian of longitude from Greenwich as east and west units, generally understood and adopted by common consent, and knowing the rate of the revolution of the earth on its axis, and the position of the fixed stars (which are so far away that they apparently have no motion), we can determine, and plot on the chart any position on the earth's surface. This is why astronomy is the basis of geography, and why it guides the movements of vessels.

It has been found by observation that when the sun comes north of the equator, we have summer in the Northern Hemisphere, and winter in the Southern, and vice versa. When the sun is farthest south of the equator, the inhabitants of Patagonia are sitting in their shirt sleeves, while those in Canada are wearing fur caps and mittens; thus astronomy is the basis of our time calendar, as well as our geography; and it will be seen that the Hydrographic Office needs an astronomical observatory and skilled observers to maintain the basis of its measurements of time and ge-

ography. Having obtained these units at a vast expense of time and labor, it distributes them free to all the inhabitants of the United States, in order that our people moving East and West on our railroads can do so with certainty, without the loss of life, and that in the multitude of commercial transactions where time is invaluable, disputes involving a difference in time can be avoided. Thus the little blue signs with the white letters, "U. S. Standard Time", seen on the clocks in railroad depots, hotels, boards of trade, jewelry stores, and other public places, do in reality mark a standard which has been determined and sent out daily by telegraph by the Navy Department for the free use of the commercial world. In order to perform this service the Hydrographic Office has established a number of branches in the principal cities and seaports of the United States. From these branch offices electrically operated Time Balls are dropped at 12, noon, daily, from masts located in prominent positions, so that the general public may have this unit of time freely, without going to the expense of putting in electrical time-keeping machines, as is done by railroads, watchmakers and others who use it professionally. When we consider how intimately the affairs of the world are bound up with the unit of time, it will be seen that the correctness of this unit is very important. It will be sufficient to say, that every man's payday depends upon it; his time of starting and quitting work; his holidays; his rent days; even wash days.

Probably the largest expenditure of the Bureau consists in the expense of chart making and collection. I mentioned the fact that original surveys are made by officers of our men-of-war, but it must not be understood that the chart construction of the Hydrographic Office ends with these. Realizing that our naval force was not large enough to cover all the waters of the world, international exchanges have been arranged with similar departments of other governments, by means of which copies of all data of value are forwarded to each capital as soon as received, to be utilized in preparing and correcting the charts of that government. So far all governments may be said to have followed the same general plan, but it remained for the United States Hydrographic Office to outline, adapt and improve to its present state of efficiency the system of co-operation which has aroused the admiration of all civilized peoples. Early in its career it became evident to the officers in charge that charts, to be of value, must

be kept corrected up to date, and that obsolete or incorrect charts are not only useless but are positively sources of danger to navigators.

To obtain promptly and correctly all changes of bottom or currents, or new discoveries relating to navigation, it was found necessary to interest as reporters the people the most to be benefited, the sailors of the world's mercantile marine, whose ships dot every sea. Consequently, the "Notices to Mariners," a weekly issue, containing corrections for charts, sailing directions, light lists, etc., was begun, and the reports received in exchange prepared and sent all over the world. Sailing directions and other nautical publications are published and put in their hands, and every possible means that the appropriation allowed of, warning them of dangers to navigation and assisting them to avoid the perils of the rocks and shoals, was adopted.

(To be continued.)

In a recent letter to the editor, Herman C. Cooper, Assistant Professor of Chemistry, Syracuse University, says of the value of SCHOOL SCIENCE AND MATHEMATICS:

The practical hints are valuable to teachers in the schools, but I cannot help thinking that it is the meaty articles which give the paper substantial and lasting value. I recently indexed my file of SCHOOL SCIENCE AND MATHEMATICS with regard to the Teaching of Chemistry in secondary schools, on which I am now conducting a course, and was much impressed with the valuable contributions to this subject made and secured by Dr. Newell. Even some of his write-ups of speeches and discussions at conventions make splendid references for intending teachers. Any article along the lines of Smith's Teaching of Chemistry and resulting from practical experience would not be "old" to *any one* engaged in teaching chemistry. There are 1001 problems connected with teaching chemistry whose discussion would be as valuable to the world as scientific research, I think.

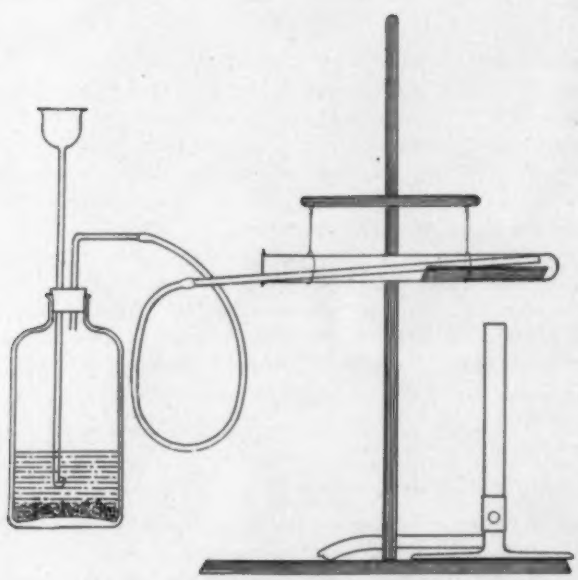
STUDENT'S NOTES ON A QUANTITATIVE EXPERIMENT.

BY FRANK SQUAIR,

Hyde Park High School, Chicago. Oscar R. Flynn, Instructor.

Object: To show the difference between a free element and an element in combination.

(a.) Sulphur was put in a test tube and heated; a stream of hydrogen was passed through the test tube. In a few minutes all the sulphur had been removed by hydrogen. This shows that free sulphur vapor may be removed in a stream of hydrogen.



(b.) About a gram of sulphur was again heated, and when the vapor filled about one-half of the test tube, a warm strip of copper was dropped in. The strip was about 5 cm long and weighed 2.86 grams.

Most of the sulphur at once disappeared; the strip became very brilliant.

(c.) The contents of the test tube were again heated in a stream of hydrogen until no more sulphur condensed on the cooler parts of the test tube. The strip was cooled in a stream of hydrogen and weighed, the weight being 3.73 grams.

(d.) The same strip was again heated with sulphur and cooled as in (c.) to find if the copper had absorbed the maximum amount of sulphur. The resulting weight was 3.8 grams.

(e.) The strip was now tested to find if all the free sulphur had been removed by reheating in a stream of hydrogen, with the following results:

First test: Weight was 3.6 grams.

Second test: Weight was 3.58 grams (additional heat used).

Third test: Weight was 3.58 grams.

Resulst (b.) and (e.) show that 0.72 grams (3.58—2.86) could not be removed from the strip in a stream of hydrogen. This is called combined sulphur.

A correspondent writing from DeKaap, in the Transvaal, dlrects our attention to methods of determining the relative density of solids which, he thinks, may not be in general use among teachers, because he has failed to find the processes described in some books on physics. We are under the impression that the methods employed by our correspondent are already familiar to most teachers, but for the benefit of any readers who have not yet adopted the plans, we repeat them here.

First method.—(i.) Weigh the given solid in air. Weight $= a$. (ii) Weigh a suitable sinker in water. Weight in water $= b$. (iii) Weigh sinker and solid in water. Weight in water $= c$. In (iii) the forces acting on the left-hand arm of the balance are the effective pull of the sinker $= b$, plus the effective pull of the solid upwards $= a$, minus the weight of water displaced by the given solid $=$ W.

... $b+a-w=c$

$\therefore w=b+a-c$

$\therefore$ Relative density required$=\dfrac{a}{b+a-c}$

Second method.—(i) Weigh the given solid in air. Weight $= a$. (ii) From the balance suspend the sinker in water and counterpoise with sand. (iii) From the balance suspend the sinker and solid in water and remove sand until equilibrium is secured. (iv) Weigh the sand removed. Weight $= d$. The weight of the sand is equal to the decrease in the downward pull on the left-hand arm of the balance caused by the suspension of the solid in water $=$ W $- a$.

$\therefore w-a=d$

$\therefore w=a+d$

Relative density required$=\dfrac{a}{a+d}$

—*School World.*

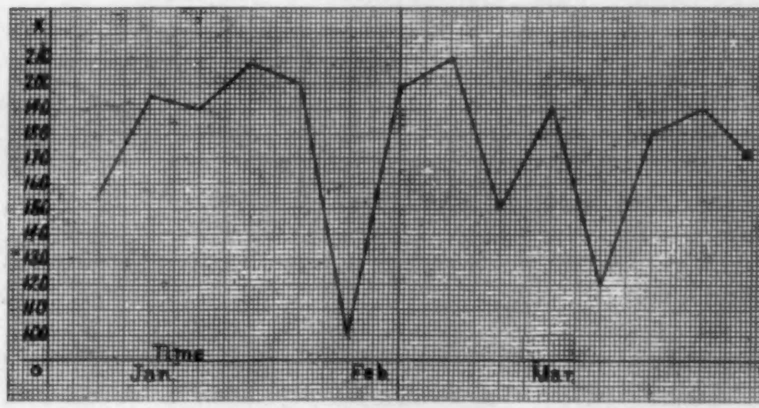
CULTURE COURSE. IV.

By T. M. Blakslee.
Central City, Iowa.

[CONTINUED FROM THE JANUARY NUMBER, PAGE 60.]

Part III. Co-Ordinate (Analytical) Geometry.

Application Sunday School. Attendance.



Here the attendance is plotted as a function of the time.

The collections, number of bibles, and other facts could be plotted on the same paper.

If the unit of money be one cent, when the attendance and collection curves across one cent per member is indicated.

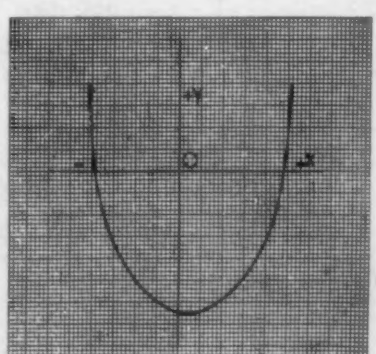
Economic Application.

The silver-price of gold might be thus plotted.

A river might be plotted from the latitude and longitude of points on the stream.

We obtain the ***graph*** of an equation thus:

For example, in $y=x^2-x-6$, we regard y as a function of x. A value of x that makes $y=0$ is a root of this equation. Whenever the curve cuts the axis of x we have a root.



x =	−3	−2	−1	0	+1	+2	+3	+4
y =	6	0	−4	−6	−6	−4	0	6

Later we shall see that this is a parabola with vertex at $(\frac{1}{2}, -6\frac{1}{2})$, the axis being vertical. (a, b) is the point $x=a$, $y=b$.

THE METHOD OF PROCEEDING.

1. All the points of the line to be considered are referred to fixed objects, by means of elements called co-ordinates.

2. The relations between these co-ordinates are expressed by means of equations called *the equations of the lines.*

3. The properties and relations of these lines are then deduced from these equations.

We translate from a statement in words to one in equations, transform these equations in various ways, then we may translate the result back.

We shall consider but two kinds of co-ordinates.

Rectangular, in which a point is determined in position, as on preceding pages, by its distance from two rays that cut at right angles.

Polar, in which we have the point's slant and slide from a given initial ray.

Ex. Construct the points: (2, 3), (−2, 3), (2, −3), (−2, −3), (−30°, −6), (30°, −9), (−30°, +6), (30°, +6).

Note. If the ratio is to be $m_1 : m_3$, (x_1, y_1) and (x_3, y_3) being the given points ane (x_2, y_2) the required point, then

$$x=\frac{m_1 x_1 + m_3 x_3}{1m_1 + 1m_3}, \text{ and } m_1 + m_3 = -m_2, \text{ whence}$$

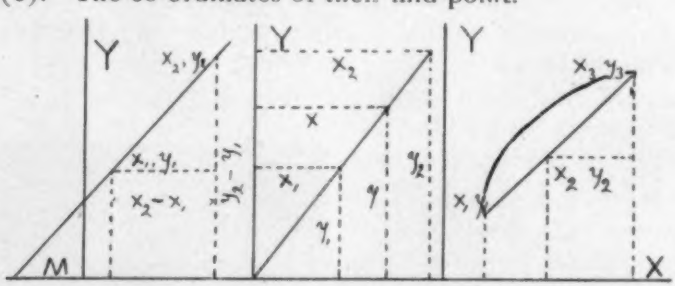
$m_1 x_1 + m_2 x_2 + m_3 x_3 = 0.$

TWO POINTS IN A PLANE.

(a). Their distance (in terms of co-ordinates).

(b). The slope of their ray.

(c). The co-ordinates of their mid-point.



m=tanM is the slope of the ray.

(a). $d^2 = (x_2 + x_1)^2 + (y_2+y_1)^2$.

(b). $m = \dfrac{y_2 - y_1}{x_2 - x_1}$

c). $x = \dfrac{x_2 + x_1}{2}, y = \dfrac{y_2 + y_1}{2}$

Ex. Apply (a), (b) and (c) to the following:

(1, 2), (3, 4), (6, 2), (8, 4) and to other like pairs of points.

Ex. The equation of a locus is an equation such that:

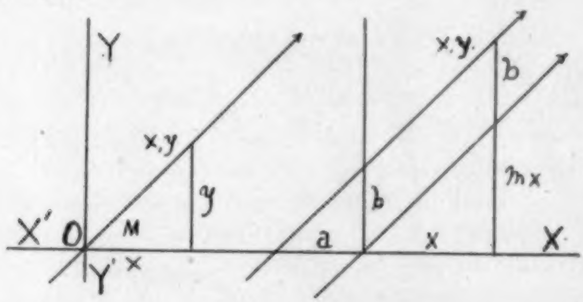
1. The co-ordinates of all points of the locus satisfy the equation.
2. No other points satisfy the equation.

Def. The locus (graph) of an equation is the ***assemblage*** of ***all points satisfying*** the equation.

Note. Strictly, the co-ordinates of the point satisfy the equation, briefly, we say: "*the point satisfies*" it.

SECTION II. FOUR FORMS OF THE EQUATION OF A RAY.

Slope Form.



Corresponding points have the same x.

I. A Ray through the Origin.

$$y = mx. \quad (\text{here } \tan M = m.)$$

II. If a and b are the intercepts cut off on axes, the y of any point in the given ray equals the y for the corresponding point in the parallel to the ray through the origin plus the intercept, b.

1. For all pointr in the ray $y=mx+b$. (S).
2. All points satisfying this equation are in the ray. How does ray change, (1) with m constant, and b variable? (2) with b constant, and m variable?

General Form. Every equation of the form

(G). $Ax + By + C = 0$ represents a ray.

Proof. $y = -\frac{A}{B}x - \frac{C}{B}$ is of form (S).

The relation of a, b and m is $m = \frac{b}{-a} = -\frac{a}{b}$.

Show this from the figures.

(*To be continued.*)

DR. BAKER'S "LOGICAL GEOMETRY."

In SCHOOL SCIENCE AND MATHEMATICS, Vol. VI, page 42, Professor Baker uses two illustrations of assumptions. Of the latter he says: "It is not axiomatic, being capable of proof." Of the former, "Any attempt to support......is futile." Even though Euclid's proof of his I......XVI "has passed muster for two thousand years," I object to it as given. I think that the assumption is capable of easy proof (the figure being drawn as on page 42).

The prolonged median has its terminus within the exterior angle above the base and the side to which the median is drawn.

Proof. The ray of the median has cut both of these rays at once.

The join of the vertex of an angle with a point within the angle lies within the angle. $\therefore \angle$ from base to join $< \angle$ from base to side.

The statement: "It is not axiomatic, being capable of proof," suggests a wrong idea of an axiom. As the ordinary addition, subtraction, multiplication and division axioms are "capable of proof" if we admit the axiom, 'A quantity may be substituted for its equal," none of these axioms are "axiomatic" with Dr. Baker's use of terms. T. M. BLAKSLEE.

Ames, Iowa.

GLUCOSE A HARMLESS PRODUCT.

Writing under the topic "Safe Foods and How to Get Them" in the January *Delineator,* Mary Hinman Abel makes the assertion that glucose, or corn sugar, contrary to the general impression, is not harmful. "What is needed," she says, "is honest labelling wherever it is an ingredient; in order that the purchasers may know what they are buying. The States that have strict laws hold that if glucose is present in red raspberry preserves, for instance, the label must so state, and a mixed maple syrup must own to its true percentage of this ingredient. It is said that a mixed syrup and jelly is generally sold at a lower price, and this lower price is a sufficient warning that it is not pure; but who knows what should be the price of the pure product? A guarantee is needed in the true label, just as pork should not be allowed to figure in the guise of "Potted Chicken" nor by veal labelled "Devilled Crab." The truth about glucose is this: It is a wholesome food, although less sweet and highly flavored than our older sweets. It is cheap; it ought to be openly sold on its own merits. The ignorance and prejudice of the buyer are largely responsible for the present situation. A few States require the honest label, fewer execute the law. The remedy is more intelligence on the part of the consumer.

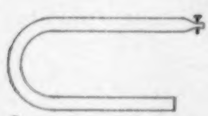
Ask for the honest label

THE ANALYSIS OF AIR.

J. A. GIFFIN,

Collegiate Institute, St. Catherines, Ont.

The following simple experiment, which I have devised, to show the percentage of oxygen in air may be performed in about ten minutes in the presence of the class. It is a most satisfactory method to show the analysis of any mixture of gases as well as that of air. For the purpose use a U tube with stop-



cock, as in the diagram, as recommended by Prof. Reynolds for the analysis of Hydrochloric Acid. If the tube is not already graduated, carefully mark on the glass by means of a file or fine thread the quantity of air to be analysed. This may be done by pouring water into the tube until it reaches the mark, when the tube is inverted and the stopcock is closed. Pass the water into a graduate and measure carefully. Now fill the tube with the air to be analysed. Pour a solution of Caustic Potash into the tube until it reaches the same level in each arm and as high as the mark on the tube. Close the stopcock. The air may be washed to get rid of the Carbon Dioxide. Now prepare a solution of Pyrogallic Acid and pour it into the open arm until it is full. Place a small piece of paper over the mouth to prevent the solution from staining the hand. Place the thumb tightly over the mouth of the tube and invert, washing the gas carefully. When through washing pass the gas into the closed arm and remove the thumb. More solution may be added to fill the tube and the gas again washed. Remove the liquid in the open arm until it is the same level in each arm. Carefully mark the level of the liquid in the closed arm. Pour out the solution and measure the space occupied by the Nitrogen by means of give the Oxygen absorbed. Temperature and pressure must be the graduate. The difference between the two readings will observed at the beginning and end of the experiment.

PROBLEM DEPARTMENT.

PROFESSOR IRA M. DELONG,
University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Solutions and problems will be duly credited to the author. Address all communications to Ira M. DeLong, Boulder, Colo.

ALGEBRA.

4. To complete a certain work, A requires m times as many days as B and C together; B requires n times as many as A and C together; C requires p times as many as A and B together; compare the times in which each would do it, and prove that

$$\frac{1}{m+1}+\frac{1}{n+1}+\frac{1}{p+1}=1.$$

Remark by the Editor:

This problem permits two interpretations; the first was printed last month. Another solution based on the same interpretation was received from Albertus Darnell too late for crediting in the January issue. In our opinion the following is also legitimate.

Solution by Emma Hyde, A. B., Iola, Kansas.

Let A, B, C denote the number of days required by A, B, C respectively to complete the work.

Then $A=mB+mC\ldots\ldots(1)$

$B=nA+nC\ldots\ldots(2)$

$C=pA+pB\ldots\ldots(3)$

Eliminating A from (2) and (3) we have

$pB(n+1)=nC(p+1)$ or

Eliminating B from (1) and (3) we have

$$Ap(m+1)=mC(p+1) \text{ or } \frac{m+1}{p+1}=\frac{mC}{Ap} \quad (E)$$

Eliminating C from (1) and (2) we have

$$nA(m+1)=mB(n+1) \text{ or } \frac{m+1}{n+1}=\frac{mB}{nA} \quad (G)$$

Adding (E) and (G) and $\left(\frac{m+1}{m+1}=\frac{mA}{mA}\right)$ we have

$$\frac{m+1}{n+1}+\frac{m+1}{p+1}+\frac{m+1}{m+1}=\frac{mB}{nA}+\frac{mC}{pA}+\frac{mA}{mA} \quad (K)$$

$$=\frac{m}{A}\left[\frac{B}{n}+\frac{C}{p}+\frac{A}{m}\right]$$

Or from (1), (2) and (3), $\frac{B}{n}=A+C$, $\frac{C}{p}=A+B$, $\frac{A}{m}=B+C$ we get

$$\frac{1}{n+1}+\frac{1}{p+1}+\frac{1}{m+1}=\frac{m}{A(m+1)}\left[2A+2B+2C\right]$$

$$=\frac{2Am}{A(m+1)}+\frac{2Bm+2Cm}{A(m+1)} \quad (L)$$

But Bm+Cm=A from (1), substituting in (L)

$$\frac{1}{n+1}+\frac{1}{p+1}+\frac{1}{m+1}=\frac{2Am+2A}{A(m+1)}=2$$

Also solved in this manner by E. L. Brown.

7. *Proposed by Mary Clemmer Tracy, Passaic, N. J.*

a) Solve $1-\sqrt{x}+y=0,\quad 4-x=y-\sqrt{y}.$

Solution by H. C. Whitaker, Ph. D., Philadelphia, Pa.

Let $v=\sqrt{x}$, $z=\sqrt{y}$, then by substituting and eliminating each unknown in turn we have

$v^4+2v^3-9v^2-11v+26=0$

$z^4+3z^3-\ z\ -\ 3\ =0.$

$v=2,\ 1.6135, -2.8067\pm0.4236\sqrt{-1}$

$z=1,\ -0.7832,\ -0.1084\pm1.9541\sqrt{-1}.$

We may therefore write

$v=2,\ 1.6135,\ 2.8385\ (\cos 188^\circ\ 35'+i\sin 188^\circ\ 35'),$

$2.8385\ (\cos 171^\circ\ 25'+i\sin 171^\circ\ 25')$

$z=1,-0.7832,\ 1.957\ (\cos 129^\circ+i\sin 129^\circ),\ 1.957\ (\cos 241^\circ+i\sin 241^\circ).$

Hence, squaring the modulus and doubling the argument

$x=4,\ 2.6033,\ 8.057\ (\cos 377^\circ\ 10'+i\sin 377^\circ\ 20'),$

$8.057\ (\cos 342^\circ\ 50'+i\sin 342^\circ\ 50').$

$y=1,\ 0.6135,\ 3.831\ (\cos 258^\circ+i\sin 258^\circ),$

$3.831\ (\cos 482^\circ+i\sin 482^\circ).$

Also solved by R. S. Pond, E. L. Brown, Byron Cosby, Grant Grumbine, Sadie H. Nelson.

b) Solve $x^2+y^2=13 \ldots\ldots(1)$

$x^3+y^3=35\ldots\ldots(2)$

Solution by E. L. Brown, M. A., Denver, Colo., and Emma Hyde, A. B., Iola, Kansas.

From (2), $(x+y)\,(x^2+y^2-xy)=35 \ldots\ldots\ldots\ldots(3).$

From (1) and (3), $(x+y)\,(13-xy)=35 \ldots\ldots\ldots\ldots(4).$

From (4), $3x^2y+3xy^2-26\,(x+y)+105=0 \ldots\ldots\ldots\ldots(5).$

From (2) and (5), $x^3+3x^2y+3xy^2+y^3-39\,(x+y)+70=0$

or $(x+y)^3-39\,(x+y)+70=0 \ldots\ldots\ldots\ldots(6).$

From (6), $[x+y-5]\,[x+y-2]\,[x+y+7]=0 \ldots\ldots\ (7).$

From (7), $x+y=5,\ 2,\text{ or }-7 \ldots\ldots\ldots\ldots(8).$

From (1) and (8),

$$x=2,\ 3,\ \frac{2+\sqrt{22}}{2},\ \frac{2-\sqrt{22}}{2},\ \frac{-7+\sqrt{-23}}{2},\ \frac{-7-\sqrt{-23}}{2}.$$

$$y=3,\ 2,\ \frac{2-\sqrt{22}}{2},\ \frac{2+\sqrt{22}}{2},\ \frac{-7-\sqrt{-23}}{2},\ \frac{-7+\sqrt{-23}}{2}.$$

Also solved by P. S. Berg, J. B. G. Welch, R. S. Pond, Byron Cosby Grant Grumbine, H. C. Whitaker, H. H. Seidell, A. J. Beatty.

8. In walking along a street on which electric cars are running at equal intervals from both ends, I observe that I am overtaken by a car

every 12 minutes, and that I meet one every 4 minutes. What are the relative rates of myself and the cars, and at what intervals of time do the cars start?

I. *Solution by Grace M. Bareis, A. B., Bala, Pa.*

Let s = distance between cars going in same direction.
Let t = interval of time between cars going in same direction.
Let x = rate of car.
Let y = rate of man.
Then, $x-y$ = rate of approach when both travel in same direction, and
$x+y$ = rate of approach when they travel in opposite directions.
By conditions of problem,

$$12(x-y) = s = 4(x+y)$$

Therefore, $x=2y$.

Also, $t = \frac{s}{x} = \frac{4(x+y)}{x} = 6.$

II. *Solution by P. G. Agnew, Pontiac, Mich.*

Let x = number of cars per hour passing fixed point.
y = number of cars per hour I should pass if cars were to stop.

Then $x + y$ = number of cars I meet per hour $= \frac{60}{4} = 15.$

$x - y$ = number of cars passing me per hour $= \frac{60}{12} = 5.$

$\therefore x=10,\ y=5.$

Therefore the interval between cars is 6 minutes, and my rate is half the speed of the cars.

Also solved by P. S. Berg, Emma Hyde, E. L. Brown, R. S. Pond, J. B. D. Welch, W. V. Stenterville, H. C. Whitaker, Albertus Darnell, H. H. Seidell, Homer Derr.

9. Find the sum of n terms of the series $1+2x+3x^2+4x^3+\ldots\ldots$

Solution by Byron Cosby, A. B., Mound City, Mo.

Denoting the sum by S_n we have

$$S_n - 2x S_n + x^2 S_n = 1-(n+1)x^n + nx^{n+1},$$

$$S_n = \frac{1-(n+1)x^n + nx^{n+1}}{(1-x)^2}$$

Also solved by H. C. Whitaker, Grace M. Bareis, R. S. Pond, H. H. Seidell, P. S. Berg, Albertus Darnell, E. L. Brown.

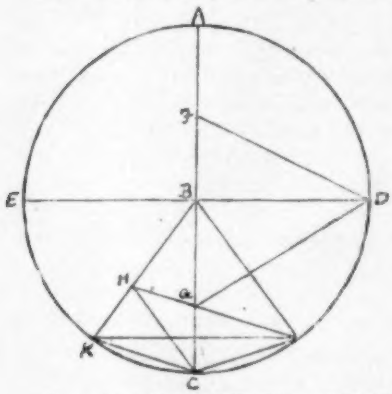
Mr. Brown points out that the sum takes the indeterminate form $\frac{0}{0}$ when $x=1$. Evaluating by the method of the Calculus he finds the sum, when $x=1$, reduces to $\frac{n(n+1)}{2}$.

A solution of Problem 6 was received from Albertus Darnell too late for crediting in the January issue.

GEOMETRY.

6. The circumference of a circle can be divided into five equal parts as follows: Draw two perpendicular diameters AC, DE, meeting at the center B. Bisect AB in F, with F as a center and FD as a radius describe a circle meeting AC in G. Then DG is a chord of one-fifth the circumference.

II. *Solution by E. L. Brown, M. A., Denver, Colo.*



Divide the radius BK in extreme and mean ratio at H; take KC, CL, each equal to BH; join BC, BL, HC, HL, KL, GD; join D to F, the middle point of AB.

In the isosceles trapezoid BHCL, LH = BC; therefore triangle LBH is isosceles and equal to BKC. Therefore angle BHG is equal to BKC, making HG parallel to KC. Hence, BG = BH.

Because triangle CHK is isosceles,

$\overline{BC}^2 - \overline{CK}^2 = BK \cdot BH$......(1)

But since BC = 2BF, CK = BG, BK = 2BF, and BH = BG, equation (1) reduces to

$$4\overline{BF}^2 = \overline{BG}^2 + 2BG \cdot BF$$

Now $\overline{FG}^2 = \overline{FB}^2 + \overline{BG}^2 + 2BG \cdot BF$

Therefore, $\overline{FG}^2 = 5\overline{BF}^2$

But $\overline{FD}^2 = \overline{BF}^2 + \overline{BD}^2 = 5\overline{BF}^2$

Therefore, FG = FD.

Because triangle LBH is isosceles,

$$\overline{LK}^2 = \overline{LB}^2 - KH \cdot KB = \overline{BH}^2$$

Therefore, $\overline{LK}^2 = \overline{LB}^2 + \overline{BH}^2 = \overline{BD}^2 + \overline{BG}^2 = \overline{GD}^2$

Therefore, GD = LK, a side of a regular inscribed pentagon. Hen e in triangle FDG, FD = FG, and GD is equal to a chord of one-fifth the circumference.

Note.—Since BG is equal to a side of a regular inscribed decagon, and GD that of a regular inscribed pentagon, we see that "the square of the side of a pentagon inscribed in a circle exceeds the square of the side of a decagon inscribed in the same circle by the square of the radius."

Also solved by I. L. Winckler.

7. *Proposed by E. L. Brown, M. A., Denver, Colo.*

In a given circle inscribe a triangle whose sides shall pass through given points.

Remark by the Editor.

The solution of this problem depends on the following: *In a given circle inscribe a triangle two of whose sides pass through fixed points and*

whose base is parallel to a given line. (See No. 10 under Problems for Solution, below.)

Let P, Q, R be the three given points, G a point on the line PQ such that PQ . PG = square of tangent from Q to the given circle.

Inscribe a triangle BCH in the circle having its sides BC, HC passing through R, G and its base BH parellel to PQ. Join QC and let it meet the circumference again in A, join AB. Then ABC is a triangle inscribed in the given circle whose sides pass through P, Q, R. For, if possible, let AB meet PG in P′ instead of P. Because BH is parallel to PQ the angles BHC and CGQ are equal (or supplementary, according to the relative positions of P, Q, R and the circle) and angle BHC = angle BAC, being in the same segment. Therefore the angles BAC and CGQ are equal (or supplementary). The quadrilateral AP′GC is therefore inscribed in a circle and AQ . QC = P′Q . PG; but by construction PQ . PG = AQ . QC. Therefore P′Q . QG = PQ . QG, and P′Q = PQ. Therefore AB passes through P.

Solved by H. C. Whitaker by the methods of Analytic Geometry.

8. Construct the triangle, if the radii of the three circles, which touch the three sides externally be given.

Solution by P. S. Berg, B. S. Larimore, S. D

Let ABC be the triangle, a, b, c the sides, $\triangle$ the area, and r', r'', r''' the radii of the three circles touching c, a, b, externally, then

$(b+a-c)\,r' = \triangle$, $(b+c-a)\,r'' = 2\triangle$, $(a+c-b)\,r''' = 2\triangle$,

$$\sqrt{s(s-a)(s-b)(s-c)} = \triangle$$

By solving these equations for a, b, c, we get

$$a = \frac{r'r'' + r''r'''}{t},\quad b = \frac{r'r''' + r''r'''}{t},\quad c = \frac{r'r'' + r'r'''}{t},$$

where $t^2 = r'r'' + r'r''' + r''r'''$.

Also solved by E. L. Brown. One incorrect solution was received.

PROBLEMS FOR SOLUTION.

ALGEBRA.

8. How many committees of 5 men each can be selected from a body of 10 men, three of whom can serve as chairman but can serve in no other capacity?

9. Of what quadratic equation is the following a root? Express the continued fraction as a surd.

$$2 + \frac{1}{2+}\ \frac{1}{1+}\ \frac{1}{2+}\ \frac{1}{1+}\cdots\cdots$$

10. If a, b, c, d form a geometric progression, show that

$$(a-d)^2 = (b-c)^2 + (c-a)^2 + (d-b)^2.$$

GEOMETRY.

10. In a given circle inscribe a triangle two of whose sides shall pass through given points and whose third side shall be parallel to a given line.

11. *Proposed by W. D. Higdon, St. Louis, Mo.*

From a point O in an equilateral triangle ABC the distances to the vertices were measured and found to be OB = 20, OA = 28, OC = 31; find the area of the triangle and the leugth of the sides.

DEPARTMENT OF METROLOGY. NOTES.

Campaign for Metric Reform. The New York Herald has started a campaign for the Metric System. Every day since Dec. 10 its columns have had leading articles on the value of this system, contrasting it with the jumble of weights and measures now in use. These articles represent the opinions of men in the various lines of business and the professions. The object of the campaign appears to be twofold, educative and promotive. As an educative factor its influence will be immense, for the articles are destined to contain all the leading reasons for the superiority of metric measures in every line of business. No person who weighs or measures anything can afford not to read them. As a promotive scheme it is unique. James Gordon Bennett has long been a resident of France where *meter* and *kilo* are as well known as *foot* and *pound* are with us. Doubtless the superiority of the French measures led him to undertake the reform. It is the first time in this country that a great newspaper has undertaken a campaign on the Metric System, and on the whole is the greatest popular movement that has ever taken place in the United States in favor of this much needed reform. It is designed to ask the people to influence congress to act at last, and petitions to that end are in circulation.

This is the best opportunity yet afforded for individual and collective work in favor of metric measures. Every educational association ought to pass resolutions in favor of it, and every individual believer in it should sign and circulate a petition for legal enactment. The House Committee on Coinage, Weights and Measures has been apathetic long enough and should be incited to "get busy." For years almost every member of the Committee has been tacitly in favor of the new system, but nothing has yet come of it—not even has it been brought up for debate outside of Committee, and very few people know that such a Committee exists, or that any bill has been introduced. That people are getting tired of this sort of thing and want reform is evidenced by the Herald articles. Let the educated and educating people of this country assert themselves and stand actively, not passively, on a reform that will revolutionize the teaching of mathematics and give the high schools and colleges mathematicians and not mere ignorant dabblers in figures. The Herald has set the pace. This is our greatest opportunity. If the people demand a law, it will be passed. Communications should be addressed to John R. O'Donnell, News editor of the Herald, N. Y. City.

R. P. W.

A New Metric Bill:—Representative L. N. Littauer of New York introduced the following metric bill, H. R. 8988, in the National House Dec. 16. It was duly referred to the Committee on Coinage, Weights and Measures.

"That from and after the first of July, 1908, all the departments of the

Government of the United States, in the transaction of business requiring the use of weight and measurement, shall employ and use the weights and measures of the Metric System."

The bill is better than recent former ones in that two objectionable features have been omitted, viz., the legal standard clause, and the exception of the public lands. The former of these items offered targets for opponents, which they at once filled with holes. There was no reason for the latter item of excepting land measure, and fortunately the present bill drops it. The bill is very brief, making no mention of appropriations for measuring and weighing instruments, which would be required in case of government usage. This is no objection, since a special bill for that purpose could easily be passed any time before July 1, 1908.

When in 1901 the bill for a National Bureau of Standards was presented it was very quickly passed (though requiring an appropriation of $250,000). because scientists and others all over the country worked for it. The Bureau of Standards benefits a few persons directly. Metric weights and measures would be an infinite boon to everybody—those who weigh and measure, those who ever use arithmetic, those who have children to educate. It would be no more difficult to pass this metric bill if people would work for it and demand it. It requires no immediate appropriation, and is not to go into operation for two and a half years, and nobody but those dealing with the government will be required to use it, though the influence of such use would be felt by everybody, and all classes of persons would become acquainted with the system.

The personnel of the C., W. & M. Com. is as follows: Southard, Ohio, (Chairman); Bowersock, Kansas; Hedge, Iowa; Cromer, Indiana; Dresser, Penn.; Wood, New Jersey; Knowland, California; Lovering, Mass.; Lilley, Penn.; Scroggy, Ohio; Gaines, West Virginia; Sullivan, New York; Hardwick, Georgia; Southall, Virginia; Heflin, Alabama; Wallace, Arkansas; and Delegate Kalanianaole, Hawaii.

R. P. W.

REPORTS OF MEETINGS.

REPORT OF MATHEMATICS SECTION.

Central Association of Science and Mathematics Teachers, Friday Afternoon.

Vice-Chairman J. V. Collins, of Stevens Point, Wis., presided, owing to the absence of the Chairman, Prof. H. E. Cobb. in Germany. Mr. Collins opened the meeting by reading a letter from Mr. Cobb in which he spoke of the Prussian schools.

Prof. J. W. Withers, of St. Louis, was unable to be present. His paper was read by Mr. S. A. Douglas, of the St. Louis High Schools. The title was "The Straight Line in Geometry." It was highly technical and philosophical, and discussed the popular conception of the straight line, the various scientific definitions proposed and the relation of the definition of the straight line to Euclid's parallel axiom.

Mr. W. S. Bass, of the Francis W. Parker School of Chicago, gave

an account of a combined course in algebra and physics. To first year high school pupils he gives arithmetic and easy algebra; to second year pupils algebra and physics. The work was given seven periods a week, each period forty-five minutes. The aim was to include one-half year's work in physics and algebra through quadratics, but this was found to be too much for the time allowed. An outline of the course was given. The method pursued throughout was first to show the need of a process through the study of some physical law; secondly to teach the process needed, and lastly to give a large number of problems for drill. Mr. Bass reported that the results seemed quite satisfactory. Pupils did not ask the use of algebra and acquired considerable facility in application of information learned.

Miss Mabel Sykes, of the South Chicago High School, spoke of the need of practical problems in geometry and gave illustrations from surveying and elementary architectural drawing.

Mr. N. J. Lennes, of the Wendell Phillips High School of Chicago, read a paper on "Interest and Progress in the Teaching of Mathematics." He outlined the various new methods that have been suggested in the last few years, the difficulties encountered by teachers who are trying to use these, and the influences at work favoring such use. These influences are the enthusiasm of teachers, pedagogical courses given in universities and normal schools, new text-books, and experiments performed in various institutions.

Saturday Morning.

At the opening of the session the following officers were elected for the coming year: J. V. Collins, of Stevens Point, Wis., Chairman; A. E. Slaught, of University of Chicago, Vice-Chairman; Miss Mabel Sykes, of South Chicago High School, Chicago, Secretary.

The committee appointed last spring by the Chairman of this section to consider the suggestions of the Association of Mathematics Teachers of New England, concerning the standard list of propositions for elementary geometry, submitted the following report:

The New England association seems only to have had in mind to define a body of geometrical truths which may be regarded as constituting the content of elementary geometry, and to introduce a standard system of numbering which may serve the purpose of reference in defining entrance requirements and of convenience in pedagogical discussions. The report states explicitly that no attempt is made to suggest a logical order of sequence and urges that in the teaching of geometry emphasis be laid on the fact that a variety of arrangements of theorems essentially different, but logical, is possible. In short, the report deals with the contents of elementary geometry not with pedagogical problems involved. So far as the advantages sought in the report are concerned, namely convenience of reference and readiness of classification, it is the opinion of your committee that it meets all practical needs. We, therefore, recommend its adoption.

Since, however, the value of such a system of enumeration depends

on its being generally adopted, it is hoped that no use will be made of it until it has been so widely adopted as to insure its general use.

(Signed) E. J. TOWNSEND, University of Ill.,
G. W. GREENWOOD, McKendree College,
C. A. PETTERSEN, Jefferson High School, Chicago.

The report was adopted. The committee also urged that a committee be appointed to consider the relative importance and sequence of theorems, the importance of postulating certain propositions, and other questions of pedagogical interest in teaching elementary geometry. It was voted that such a committee be appointed. The Chairman appointed the members of the previous committees and in addition Prof. C. E. Comstock, of Peoria, Ill., and Prof. C. W. Newhall, of Faribault, Minn.

Owing to enforced absence of Prof. Aley, of University of Indiana, Prof. H. E. Slaught read a paper on "Aims in Algebra Teaching." Six aims were discussed: (1) to keep in close touch with arithmetic; (2) to make frequent connection with concrete geometry; (3) to anchor algebra to the concrete; (4) to strive for the best adjustment of essentials and non-essentials; (5) to seek educational and cultural values; (6) to maintain the interest at high pitch by all worthy means. The last aim is best served by the accomplishment of the other five.

The discussion was opened by Miss J. J. Bullock, of Champaign, Ill. She emphasized : (1) the necessity of anchoring algebra to arithmetic by use of percentage formulas and the like; (2) the fact that algebra is a linguistic study, and in it the pupil learns to say accurately and economically what he has known before; (3) the translation of formulae; (4) the use of apparatus made by members of the class. As to the introduction of problems, physics, engineering and the like, she thought that words might not mean the same thing to different people and calls attention to the fact that "no man can serve two masters." She thought the graph helpful in the study of the equation as a means of translation.

Miss Bullock gave the following outline of Prof. Aley's paper: The aim is to know algebra for its own sake; it has a practical value and a cultural value. Its cultural value is: (1) to teach generalization; (2) to learn to recognize types; (3) to cultivate mental alertness, directness of method and to give habits of accuracy.

The following persons took part in the discussion: H. S. Wright, of Cedar Falls, Iowa; G. S. Shutts, of Whitewater, Wis.; G. W. Greenwood, of McKendree College, Ill., and C. W. Newhall, of Faribault, Minn. The following points were emphasized: aims are two-fold, acquisition of power and facility in application; drill in translation of formulae is essential; emphasis on the history of algebra develops interest.

Mr. C. A. Pettersen, of Jefferson High School, Chicago, read a paper entitled: "Some Thoughts on the Teaching of Geometry." He said that most new methods are a reaction against the controlling use of the text-book, and discussed the legitimate use of the text-book. Logical vigor is a growth and cannot be imposed ready made. The subject matter must

be psychological and various means may be used to develop and hold the interest, but improvements must come in the changed attitude of the teacher, not in the text.

The paper was discussed by Prof. G. W. Shutts, of Whitewater, Wis. He said that geometry is a tool not only for material application, but also for the furnishing of the mind. It is necessary to give pupils habits of thought in deduction and in recognition of beauty. It is well to show the use of theorems in making other demonstrations; for this purpose it is often desirable to depart from the exact order of the text. Prof. Shutts also discussed certain class room essentials and gave some good examples of practical applications. MABEL SYKES, Secretary.

ASSOCIATION OF TEACHERS OF MATHEMATICS OF THE MIDDLE STATES AND NEW ENGLAND.

The annual meeting of the Association of Teachers of Mathematics of the Middle States and Maryland was held on Saturday, December 2, at Annapolis, Md., in affiliation with the Association of Colleges and Preparatory Schools of the Middle States and Maryland. The following papers were read:

1. How Should the College Teach Analytic Geometry.—Professor H. S. White, Vassar College.
2. Suggestions for the First Twelve Lessons in Demonstrative Geometry.—Mr. H. R. Higly, Pennsylvania College.
3. Some Essentials of the Successful Mathematics Teacher.—Dr. John S. French, Jacob Tome Institute, Port Deposit.
4. The Teaching of Geometry.—Dr. H. A. Converse, Baltimore Polytechnic Institute.

The officers elected for next year were:

President, Professor E. S. Crawley, University of Pennsylvania.

Vice-President, Dr. John S. French, Jacob Tome Institute, Port Deposit, Md.

Secretary and Treasurer, Dr. J. T. Rorer, Central High School, Philadelphia, Pa.

The Association adopted the following resolution:

"RESOLVED, That this Association approve of the organization of a national federation of existing associations of teachers of mathematics in which each association shall preserve its own organization and individuality and which shall have among its objects the joint support of publication. In the federation should be included only societies representing territory as extensive at least as one state."

THOMAS S. FISKE.

ASSOCIATION OF MATHEMATICS TEACHERS OF NEW ENGLAND.

The third annual meeting of the Association of Mathematical Teachers in New England was held at Boston, Saturday, Dec. 9, at Huntington Hall. Mr. Edgar H. Nichold reported for the delegates to the conference at Asbury Park of last July, and read the constitution for the national association of teachers of mathematics and science. Time was lacking for a discussion of the constitution. Professor H. W. Tyler of the Massachusetts Institute of Technology offered two resolutions, which were adopted by the association. The resolutions are:

"Voted, That the Association of Mathematical Teachers in New England hereby expresses its recognition of the importance of co-operation between the local associations of teachers of mathematics and science.

"Voted, That it is the sense of the Association that the ends desired can be best promoted under present conditions by the organization of a National Joint Committee, representing the local associations, and having such functions and powers as may be from time to time delegated to it by the respective associations. Such functions might include the publication of a periodical and the representation of the work of the local associations in the programmes of the National Educational Association."

Mr. John P. Clark of the Lynn Classical High School, read a paper, "The Attitude of the Teaching Public Toward Mathematics."

Mr. Clark stated that he had written to eighty teachers of physics and chemistry. That every teacher replied that he required the use of arithmetic and algebra as tools for the study of science. The majority reported dissatisfaction with the preparation of their pupils in mathematics and stated that pupils were not as well prepared as they were twenty years ago. Weakness in mental arithmetic was a general complaint.

A series of experiments with examinations in arithmetic at the Lynn High School and the Boston English High School was discussed. The results of these examinations were similar to those obtained by Professor Norris of Simmons College. Many pupils could not solve questions like: "Find 3 per cent of 81."

General Francis Walker in 1887 advocated the abridgment of the course in arithmetic. Reform was needed, but the authority of General Walker brought changes greater than he intended. The introduction of new studies in the grammar school led to the sacrifice of essential parts of arithmetic.

The school authorities of Boston have put into practice an elective system which allows a pupil to complete the high school course without mathematics. In the requirements for teachers who apply for a Boston certificate mathematics is an elective. A specialist is required for French or German, but any one is considered competent to teach algebra.

Correspondents offered the following suggestions: Students need more careful drill in percentage, decimals, ratio and proportion.

The metric systetm should be taught in grammer schools. There is a serious danger that elective systems may remove too many difficulties

from the path of knowledge. Superficial training is the inevitable result.

The Demand of Industrial Science for Mathematics was presented by Mr. Lewis Saunders, of the General Electric Company. Mr. Saunders stated briefly the mathematics needed by the mechanic, the accountant and the engineer. He showed how applied mathematics had revolutionized the construction of machines.

The experience of the speaker with graduates of high schools and colleges did not lead him to think that they had not had sufficient drill. He had found them deficient in applying their mathematics. They lacked ability to take a physical problem, separate it into its mathemaitcal elements, and put it into such a form that it is readily solved. They were faulty in applying formulas. They made careless errors in measurement and reading scales.

At the General Electric Company a school for apprentices is maintained. Practical problems from the shop are taken.

The speaker gave illustrations from his experience in convincing students that they could think for themselves. He showed them that they were too ready to ask for help.

WILLIAM A. FRANCIS.

REPORT OF MEETINGS OF PHYSICS SECTION, C. A. S. AND M. T., DECEMBER 1 AND 2, 1905.

The first meeting of the Section, December 1, was called to order by Chairman A. A. Upham, who introduced Mr. L. F. Miller, of the University of Wisconsin, who presented a paper on "The Value of the Qualitative Experiment in Physics."

In the discussion which followed, Mr. A. H. Sage agreed with Mr. Miller that it is necessary to keep up interest and to allow for the varying capacities of our pupils. Mr. V. D. Hawkins expressed the belief that formulae should be left out of many quantitative experiments. Mr. C. F. Adams expressed surprise at the statement that Physics is becoming unpopular, saying that this is not so in Michigan, despite the fact that quantitative experiments are used.

A paper on "The Aim of High School Physics Teaching," by E. E. Burns, Medill High School, Chicago, was next presented.

Mr. F. R. Nichols stated his belief that *interest* is as near a cure for all the ills of Physics teaching as anything of which he knew.

Mr. A. H. Sage, as Chairman of the Committee on Reference Books in Physics reported that the committee had now a descriptive list of more than 300 books, which would be turned over to the Executive Committee of the Association. Moved, seconded and carried that the report be accepted and that the thanks of the Section be given.

Following this was a valuable paper on "The Teaching of Physics," by Mr. H. N. Chute, of the High School, Ann Arbor, Mich., which was followed by a discussion in which several of those present participated.

Mr. L. B. McMullen, of the Shortridge High School, Indianapolis, gave "a plea for more simple apparatus," illustrating his theme by dem-

onstrations of a Jolly Balance made by him at a cost of $1.00, with which most of the experiments possible on the more costly instruments could be performed; a sonometer constructed from a cigar box (the virtues of dead black Jap-a-lac as a finish for apparatus were mentioned); a new device for determining the coefficient of expansion of a rod; and by a diagram of a very simple means of finding the latent heat of steam.

Mr. C. R. Mann mentioned a French book along the same line which would be of interest. Mr. C. E. Linebarger commended the new Jolly Balance. Mr. C. R. Mann questioned whether the High School is the place for quantitative work to the thousandth of a millimeter, etc.

Moved and seconded that the Executive Committee be requested to have members bring samples of home-made apparatus to the next meeting. Carried.

Discussion of several questions followed.

(1) Should the attitude of the student be that of discoverer or verifier?

Mr. F. R. Nichols—"Sometimes one and sometimes the other."

Mr. Stokes—"He cannot be a discoverer. Try it by saying, 'Here's your apparatus. Discover the laws of the pendulum.'"

Mr. H. N. Chute—"In a certain sense a student may be called a verifier. I am at a loss for the right word."

Mr. A. A. Upham—"Should the student first be taught Boyle's Law and then use the tube?"

Mr. Chute—"My class work is two or more weeks ahead of the laboratory."

Mr. Upham—"Then according to many you are a heretic."

Mr. Chute—"I am."

Mr. Mann—"I agree with Mr. Chute's plan."

Mr. McMullen—"I agree except in the matter of length of time. I believe in going immediately from class room discussion to laboratory."

Mr. C. F. Adams—"The kind of experiment makes a difference. Qualitative experiments, as with the simple cell, should precede."

Mr. C. M. Turton—"I disagree with the whole idea of having the experiments follow. If they precede, the pupils have some faint idea of the subject when reciting."

Mr. Upham—"My pupils say they remember better when the laboratory work precedes."

Mr. W. C. Hawthorne—"I think it is about a stand-off. In my experience with a divided class those who went to the lecture first understood the laboratory work better and vice versa."

Mr. Chute—"My pupils say that the laboratory clears up the class work."

Mr. Stokes—"Did not most say, 'I really did not understand till I had the problems'?"

Mr. Nichols—"My pupils agree with those of Mr. Upham's."

Mr. L. F. Miller—"I never allow an experiment in the laboratory before it has been treated in lecture, otherwise there is so much confusion in the laboratory. I have a pupil give in his notes a concise statement of what he understands by elasticity, etc. Writing up notes thoroughly seems to elucidate."

Mr. W. E. Tower—"The qualitative experiment gives time for the pupil to work up his knowledge, and so should precede."

(2) Is consultation of two or more students on a laboratory experiment disorder?

Consensus of opinion was "No!"

(3). Is it certain that some experiments that require several hours to perform are more valuable to a student than the same time spent in reading?

Mr. Stokes—"They will always have time to read and never to experiment."

Mr. McMullen—"I am satisfied if by hook or crook, fair means or foul, they get what is in the Carhart and Chute text."

Mr. Linebarger—"It is very seldom that any pupils *thoroughly* understand the text-book. How much understanding are they to have?"

Mr. Mann—"I'll agree to show the teacher that *he* does not understand."

Mr. Upham—"I do not believe we have enough sympathy for our pupils. In Physics there are many, many new laws to grasp."

Mr. Mann—"Why not cut out laws that are not absolutely necessary?"

Mr. G. M. Wilcox—"The student should acquire the right habit of mind toward natural phenomena and if he has acquired an interest he'll do outside reading."

(4). How many times is it profitable for a student to perform certain experiments for greater accuracy, as, for instance, finding the latent heat of vaporization?

Mr. Linebarger—"My pupils must come within a certain per cent."

Mr. McMullen—"I don't like that idea."

Adjournment. CHAS. W. D. PARSONS, Sec'y.

The second meeting of the Section was called to order by the Chairman at 10:00 a. m. December 2nd.

The nominating committee made its report naming A. H. Sage, State Normal School, Oshkosh, Wis., Chairman, S. B. McMullen, Shortridge High School, Indianapolis, Ind, Vice-chairman, and F. R. Nichols, R. T. Crane High School, Chicago, Secretary. On motion these gentlemen were elected to the respective offices for the ensuing year.

Moved and carried that a committee of three be named by the chair to report on matters of interest from the physics section of the N. E. A. at its next meeting and to confer with the committees of that body on a physics syllabus and such other matters as may seem to need attention. The chair named for this committee Mr. C. R. Mann, Chicago University, C. H. Smith, Hyde Park High School, Chicago, and C. F. Adams, Central High School, Detroit.

The section meeting then adjourned to meet with the Chemistry section for joint session. At this joint session two very interesting papers were presented. The first was by Mr. Louis Kahlenberg, of the Wisconsin State University, on "The Nature of the Process of Osmosis." The second paper was by Mr. Charles T. Knipp, of the University of

Illinois, on "New Theories of Matter in Relation to Chemical and Physical Theory."

Adjournment. A. H. SAGE, Secretary pro tem.

REPORT OF THE BIOLOGY SECTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATIC TEACHERS.

The meeting was called to order at 2:00 p. m., Friday, December 1st, 1905, by the chairman, Mr. A. H. Conrad, of the R. T. Crane High School, of Chicago, Ill.

A committee consisting of Prof. Fred L. Charles, of the State Normal School, of DeKalb, Ill., Mr. Oscar Riddle, of the Central High School, of St. Louis, Mo., and Miss Smallwood, of Chicago, was announced, to nominate officers for the 1906 meeting.

Mr. Riddle then presented a paper upon the subject: "What and How Much can be done in Ecological and Physiological Zoology in Secondary Schools?" He made a plea for the greater prominence of physiological work in the teaching of zoology. For example, some of the text books most generally used do not even contain the word "enzyme," much less any account of their occurence and action in the animal body. Yet when we consider that zoology is dynamic, not static, how can we be content with the study of dead animals? Animal ecology is not a subject which lends itself to indoor laboratory study, to any considerable extent; so physiology, not ecology, must be the revivifier of the old morphological course in the case of zoology.

Mr. W. W. Whitney, of the South Chicago High School, chairman of the committee which was appointed last year to consider and report upon the course of study in zoology and botany for secondary schools, then presented the report which has already been printed in SCHOOL SCIENCE AND MATHEMATICS. He explained that the different points here developed, embody the experience of teachers who are trying to formulate the new course that shall be distinctively for the high school, and not an adaptation of college courses in biology. He further emphasized the need for the clear definition of the high school course, and for uniformity in its requirements among different schools; since both zoology and botany are fast gaining ground as subjects which may be offered for college entrance. e. g., the recent decision of the University of Chicago to recognize the year's full course in either, for entrance, on the same basis as that of the subject of high school physics, is a case in point.

In the absence of Prof. G. H. Bretnall, of Monmouth College, his paper, "Should Botany and Zoology be taught in Full Year Courses?" was read before the section. The advantage of giving the two half-year courses, he said, is in the fact that the student thus gets a view of the whole subject of biology which is of great value to him. On the other hand, the crowding of so much material into so short a time gives the student bad mental habits, because there is not time enough for the adequate development of the subjects treated; so that it is on the whole better to study one side well, than to study both sides hastily.

Miss Elma Chandler, of the Elgin, Ill. High School, then presented

a second phase of the committee's report, "The Relative Emphasis to be Given to Morphology, Physiology, Ecology, and Other Phases of Biology." Morphology, she said, excels in the development of accuracy of observation, and is thus and otherwise, of great disciplinary value; while the physiological line of experimentation most of all, perhaps, teaches the pupil to be honest, and to think for himself. Both ecology and physiology develop the sympathetic attitude in the student, and widen his interests and outlook. Economic biology not only has great informational value, but it also renders great service in emphasizing the meaning of contact of plants and animals with our race.

Prof. Charles, of the DeKalb Normal School, then discussed the question, "What, How Much, and How Field Study May be Taught?" He suggests the giving of one year of introductory general biology, then of a second or advanced year which is to be divided between the two subjects of zoology and botany. The place of field study, in any case, would be a large one; since to observe How Animals and Plants Live (not Die), one must go into the fields The field, however, should not be literally only the meadow, but should include the whole world around us; since our aim is to produce the citizen and not the scientist. Some of this field work will be done in the garden, planting seeds; in the streets of one's native town, determining how a greater variety of trees may be introduced, what birds are and what ones ought to be nesting there, what are the relations of squirrels to the welfare of trees and other plants; and in the shops and markets and wherever animals and plants are being handled and used. So that the term "field study" comes to include some of the material called nature study and some of that used in commercial geography, but still more of that belonging to economics. As for the collection of specimens, perhaps a good criterion would be the rule that each pupil is to get his own material for laboratory study; then, too, we should be sure that he is not studying what is beyond his own environment. A good division of time would be, one-fifth of the work in the field, two-fifths in the laboratory, and two-fifths spent in recitation and discussion; with the proviso, however, that laboratory time will often be used for the interpretation of material collected in the field.

Miss Amelia McMinn, of the West Division High School, of Milwaukee, Wis., presented the last point in the discussion based on the committee's report, viz., "In what Order should Animal and Plant Groups be Studied?" She expressed a preference for the fall study of insects because of the opportunities it gives for first-hand observation work in natural history; and she considers it desirable to avoid the difficulties incident to interpretation of obsevations made with the microscope, for the first few weeks at least; since such difficulties are considerable even for us of larger experience, how much more serious must they be for the beginner? The pupil will be able to get better manual training elsewhere than that which he obtains in making animal dissections for himself; so whatever material of this sort seems indispensible, would better be furnished to him ready for use. Finally, the important question is not, "What order do you use?" but rather, "What Reason have you for using that order?"

In the informal discussion which followed, Prof. J. G. Needham was one of the first speakers called for. He urged, among other things, the necessity for the reduction of subject matter to better form in both physiology and ecology.

Prof. N. A. Harvey thinks that since we must, under existing circumstances, usually combine zoology and botany in the one year course, we should do well to use the subject matter of each in different ways; e. g., zoology can best be made to illustrate classification, botany to illustrate physiology.

Prof. Smith, of the zoological department of the University of Illinois, emphasized the fact that one of our central aims is to develop the scientific habit of thought in the pupil; and that there is great need of the devising of a larger number of well-planned, practicable experiments for that purpose.

Dr. Davis, of the botanical department of the University of Chicago, inquired concerning the fate of what we used to call "home reading"; and suggested some parts of Dr. Jordan's texts as illustrating the interesting style and the development of some definite line of thought, which should characterize such material.

There was some discussion as to whether the report of the committee on the course of study in zoology and botany should be formally adopted; some objections were raised as to individual points in the report; and several members of the committee thought such adoption altogether undesirable. However, the section insisted upon formally tendering its thanks for the good and helpful work done by the committee. Upon motion and vote of the meeting, the report of the committee was then accepted and the committee discharged.

The section then adjourned.

Saturday, December 2d, 10 a. m. Meeting called to order by Chairman Conrad. The nominating committee reported the names of Mr. W. W. Whitney, of Chicago for chairman, Mr. C. R. Clark, of Indianapolis, for vice-chairman, Miss Elma Chandler, of Elgin, Ill, for secretary. On motion the secretary cast the ballot for the section for the above named officers.

An informal discussion as to the character of the laboratory notebook followed. Mr. Mitchell, of the Hyde Park High School, of Chicago, maintained that it is a general criticism passed upon biology work, that it is "choppy," not well sustained. More than ever now that zoology and botany are beginning to be more widely credited for college entrance, we must have the notebook complete in detail and ready for inspection. The method he suggested is, first, the correction of the notes in the brief form in which the student first takes them down, in the laboratory; then after the laboratory work has been finished and recited upon, these notes should be rewritten into detailed, completed thesis.

Prof. I. N. Mitchell, of the Milwaukee Normal School, also spoke in favor of the carefully corrected and elaborated notebook.

Mr. Lucas, of the Englewood High School, objected to the writing of notes outside the laboratory as being likely to foster careless and wrong habits on the part of the student.

Miss Chandler, of Elgin, Miss Smallwood, of Chicago, Mr. Holferty, of St. Louis, and others, suggested the possibilities in the way of the substitution of sketches for much of the note-taking which at first thought seems indispensible, and which takes so much of the students' and of the teachers' time.

Mr. Mitchell suggested that some uniformity in the length of time devoted to the subjects of botany and zoology is desirable; at least six periods being necessary, he thought, per week, so that there would be one double laboratory period. However, one hundred hours of laboratory work should be accomplished during the year.

A demonstration was given by Mr. Cole, of Lake View High School, Chicago, Ill., with the projection of living animals partly anaesthetized by means of a weak solution of chloretone. The immense advantage of the use of the lantern with the whole class, over the use of the microscope by the individual student lies in these facts: One is thus made sure that teacher and student have in mind the same image at the same time—a condition which should ever be the true aim of the teacher to accomplish, but which is almost impossible of realization when each student has a different specimen and then, too, each specimen, being alive and constantly changing, varies from moment to moment. This difficulty partly accounts for the fact that so many teachers have been willing to give so-called zoological courses which consist mostly of the study of the dead, not living, animals: Furthermore, the projection method gives the entire class the benefit of the best specimen to be obtained. Mr. Cole's demonstrations included the following and many other points: The heart action in the earthworm, the living brain and protrusible pharynx in the flatworm, the action of the mask and mouthparts in the dragon-fly larva, of tracheal and cloacal gills in different invertebrates and their larvae; slides showing Hydra in the act of devouring and digesting its prey; the action of iodine and the effect of boiling upon starch granules, etc., etc. Mr. Cole explained the technique which he has developed during a long experience with this method of illustration, and gave much valuable information as to the use of the electric current, the manufacture of suitable slides and cells, the making of cement, the manipulation of the condenser and cooling cell, etc.

After announcement concerning the excursion for the afternoon to see Mr. Edward Uihlein's collection of orchids; also concerning the exhibit from different schools of notebooks and other specimens of students' work, also of laboratory contrivances and devices which different members of the section have found helpful in their own experience, the section was adjourned. MINNA C. DENTON, Sec'y.

MEETING OF THE NEW YORK PHYSICS CLUB.

The 34th meeting of the New York Physics Club was held in the Newark (N. J.) High School on Saturday, December 9, 1905, at 3 p. m. The innovation of an afternoon meeting was tried in order to have the last number on the program, viz., "An Exhibition of the McFarland-Moore System of Lighting."

Previous to the regular meeting a visit was made to the Crocker-

Wheeler Electric Works, at Ampere, N. J. The members of the club were very cordially greeted by Mr. Dunn, the Vice-president, after which they were shown the complete method of dynamo and motor construction, including winding, planing, insulating, drying and testing. One dynamo in process of construction was pointed as of peculiar interest. Its power is 4,000 K. W. and it is to be driven by a gas engine of 5,400 H. P. This will be the largest gas engine yet built, and both are to be used in San Francisco. An interesting feature of this factory is the method of using a separate motor and sometimes two for each lathe, drill, plane or other machine used. This results in a great saving of power, as experience shows that seldom is two-thirds of the entire horse power needed for all the separate machines in use at once.

At the regular meeting, Mr. A. C. Arey, the new President, presided. During the inspection of the laboratories, which are under the charge of Mr. G. C. Sonn as head teacher of Physics, many interesting devices and methods were noted. Mr. Sonn showed the club the effects that could be produced by some large and newly imported Crooks tubes.

The first paper was on "The Alternating Current and High Frequency Effects," by Mr. W. J. Clarke, of Mt. Vernon, N. Y. Mr. Clarke used a set of apparatus of his own construction, one important piece of which was an induction coil, wound in sections of varying numbers of wire turns in each section, so that it could be used as either a "step up" or a "step down" transformer as desired. With this and other pieces Mr. Clarke performed many interesting and instructive experiments.

Mr. W. L. Grote exhibited a new form of equipotential apparatus. This consisted of a shallow cylindrical glass disk containing an electrolyte, into which dipped two electrodes on opposite sides of the disk. The disk was placed over a sheet of ruled and numbered cross-section paper, which could be seen through the bottom of the disk. A telephone receiver was placed over the head of the experimenter. To the ends of wires connecting with this receiver were attached terminals which could be inserted in the electrolyte at different places as desired. One terminal could be fixed in position in the liquid, while the other terminal could be moved to different parts of the liquid, following the regular lines of the paper below. When the points of equipotential were found by the weakening of the sound in the receiver, they were located upon another piece of C. S. paper similar to the first.

After a short business meeting the club adjourned to visit a large hardware store in Newark, in which was installed the McFarland-Moore system of electric lighting. The light emanated from an exhausted glass tube about 2 inches in diameter, which ran the length of the store and return and was bent into several angles to accommodate the sides of the building. The tube was 157 feet long and continuous. It glowed with a soft, brilliant, slightly pinkish light, making every thing as "light as day" and casting no shadows. This light is no more expensive than incandescent lamps sufficient to give the same amount of illumination would be, and since it gives very little heat, it is claimed to be more satisfactory.

R. H. CORNISH.

REPORT OF THE MEETING OF THE EARTH SCIENCE SECTION OF THE C. A. S. M. T. HELD IN CHICAGO DECEMBER 1 AND 2, 1905.

The meeting was called to order by the Chairman, Mr. J. H. Smith, who appointed the following committees: On nominations, Mr. C. S. Jewell, Miss Annie Weller, Mr. J. F. Morse; on membership, Mr. Wm. H. Chamberlin.

Dr. J. Paul Goode, of the University of Chicago, addressed the Section on "Commercial Geography for Secondary Schools." A paper was also presented by Mr. W. J. Wilson, of the United States Hydrographic Office, on "The Relation of the Work of the Hydrographic Office to Commerce." Both papers were warmly welcomed and called forth a vigorous discussion.

The nominating committee made its suggestions for officers for the ensuing year as follows: President, Mr. D. C. Ridgeley, State Normal University; Vice-president, Miss Elizabeth Smith, Chicago Normal School; Secretary, Miss Lillian Chapin, Calumet High School, Chicago. On motion, they were unanimously elected. The Section then adjourned.

L. L. EVERLY, Sec'y.

CALIFORNIA TEACHERS OF MATHEMATICS IN SESSION.

A large number of the teachers of mathematics in California have organized a section of the State Association. Their first annual meeting was held at Berkeley December 28-30. An enthusiastic audience crowded the room at both sessions. The papers and discussions were of decidedly practical value.

At the first session Mr. J. B. Clarke of the Polytechnic High School, San Francisco, joint author with Principal Bush of the new Geometry just published, read a carefully prepared paper on "Vital Questions for Teachers of Secondary Mathematics." He took a radical position on treating algebra and geometry together and favored several extensive omissions from the texts in common use in the first year in each subject. He thought that the requirement in original work was often too great as measured by the benefits received. He advocated a weekly laboratory period in mathematics

His paper was ably discussed by Prof. R. L. Green of Stanford University, Miss Elise Wartenweiler of Auburn High School, and others.

Professor Green advocated the development of the deductive side rather than the logical side of mathematics, and would take great pains to develop demonstration and cultivate the special sense in the imagination.

Miss Wartenweiler had found inventional work a fine introduction to formal geometry, and had succeeded in carrying parallel courses in algebra and geometry. The general discussion was favorable to the giving of one period a week to laboratory work.

The paper of the second day was given by Dr. Irving S. Stringham of the University of California, on "How to Cultivate the Power to Think Mathematically." He emphasized the need of a teacher who knows how to teach, who is well equipped, and who can learn from experience.

"Teach the child to read, write and speak mathematically. This is the only way to teach him to think mathematically. The language of mathematics must be well mastered. This is as important as the language of a foreign country in dealing with the matters of that country."

The discussion was led by Principal A. C. Onley of the Fresno High School. He emphasized the necessity of a mutually helpful attitude between the teacher and pupils, of both toward the subject itself. "There is great danger in going too fast at the beginning of a subject; a working knowledge of language is acquired slowly." He advised the use of "variable" instead of "unknown" quantity, and "constant" instead of "known;" "aggregate" instead of "sum."

The entire board of officers was re-elected; it constitutes the executive committee and is as follows: President, George A. Miller, Stanford University; vice-president, W. H. Baker, State Normal School, San Jose; secretary-treasurer, J. Fred Smith, Campbell Union High School; Chas. A. Noble, University of California; J. B. Clarke, Polytechnic High School, San Francisco.

The Section adopted SCHOOL SCIENCE AND MATHEMATICS as its official organ.

BOOK REVIEWS.

New Creations in Plant Life. W. S. Harwood. The MacMillan Co.

Our readers have doubtless noted various recent articles describing new plant productions, and will welcome this book, which is "An Authoritative Account of the Life and Work of Luther Burbank." Magazine articles on this topic have necessarily been too brief to give all the desired information and this deficiency is met in a large measure in the book now before us. Each of the twenty-two chapters will prove fascinating both to biologist and general reader. Books of adventure are no more enticing and this has the immeasurably greater value of being a book of fact. The stupendous work accomplished can be understood only when we get an idea of the genius, devotion and industry of the man. These characteristics of him are presented quite clearly in chapters on "Luther Burbank, the Man," "General Methods of Work," "A Day With Mr. Burbank," and "His Personality"; but to most readers these characteristics are presented in a much more potent way, though somewhat less direct, in the eleven chapters given to a description of the new creations that have been made, their origin, and the difficulties that have been overcome in reaching the final result. Throughout these chapters one is met constantly by surprises in the ways that plants behave and in the resourcefulness of the director in manipulating them. One could almost make himself believe that he is reading a fairy book written by some ingenious nature student, were it not for the frequent references to the now tolerably well known practical results of the work.

We cannot recite the long lists of these practical results, but the chapter on "Commercial Aspects of the Work" show something of the benefits that may accrue to society. It must be borne in mind that many of the experiments have been carried on for a long time and are yet far from completion. The *Amaryllis* experiment began nineteen years ago

and the one on hybrid lilies more than twenty years ago, yet neither is yet in the condition in which Mr. Burbank wishes to place it. The experimenter tries to fit his result to an average of conditions, so that it may be grown over a larger area than if it were highly specialized to a given area. This often requires more time than to produce a plant more perfectly adjusted to a small region. He has produced plants of possibilities, commercially, that hitherto have been undreamed. The extent of benefactions to society cannot be estimated. From his first production, the Burbank potato, produced while yet a resident of Massachusetts, through his long list of food plants and his floral productions to the new perfumes he has made, we find constant interest and profit, and constant opportunities for new ventures.

Those with a horticultural bent of mind will be greatly benefited by the suggestions in the two chapters on "How May I Do It, Too?" It is not quite safe as yet to make definite statements as to the bearing of this man's work. He is somewhat of a believer in transmission of acquired characters, though he has opposed to him some of the world's greatest biologists. It may be said that Mr. Burbank's work has been almost exclusively experimental, comparatively little time being given to the biological significance of his results. But one who has dealt with hundreds of thousands of plants and has learned how to produce desired results must certainly be entitled to speak on the question of whether plants do inherit acquired characters. O. W. C.

The Fern Allies of North America and Mexico. By Willard N. Clute. Illustrated by Ida M. Clute. Published by F. A. Stokes Company New York.

This book will appeal both to the general reader of popular books on plant life and to those interested in technical botany. It presents a field little known to the casual observer, possibly also none too well known to botanists. The fern allies include four orders. The first is the Salviniales, in which are the "pepperworts" (Marsilia), the "pillworts" (Pilularia); the azollas and salvinias. This is the group usually known as the "water ferns." The second order is the Equisetales or "scouring rushes," the order including but one family in which there is but one genus which has about twenty species, more than one-half of which are found in North America. The third order, the Lycopodiales, commonly known as "club mosses," includes three families, each having a single genus. The last order, Isoetales or "quillworts," has one family including a single genus. The entire collection of forms that go to make up the fern allies are to be looked upon as remnants of a formerly more abundantly represented assemblage. This fact is well proven by the reference to related fossil forms, many of which help to give a clew to the ancestry of this fern ally assemblage. This fact adds to the popular interest in the groups, and Mr. Clute's frequent references to facts of this nature add materially to his excellent work in describing existing forms.

The descriptions are clear, accurate, and as full as the space used will permit. Excellent and abundant illustrations, some of which are

in colors, constitute an indispensible feature of the work. Keys for identification follow the discussion of each family, and a check list closes the book. The author has done wisely in omitting the use of the radical terminology of some students who have recently discussed some of these forms, and also in accepting as distinct species only those forms that are fairly easily recognized as such. The book will be found interesting and helpful to all lovers of plant life. O. W. C.

Sea-Shore Life. The Invertebrates of the New York Coast and the Adjacent Coast Region. Alfred G. Mayer. (Published for the New York Zoological Society by A. S. Barnes & Co., New York.)

This is an attractive, well gotten up book of 180 pages and 119 illustrations, mostly from photographs, all new and many of them very effective.

The author has succeeded admirably in his attempt to treat the more conspicuous or interesting invertebrate animals of our eastern coast in such a manner as to interest and inform those readers who find these animals in their natural surroundings or in aquaria. Some attention is given to forms found elsewhere, including crayfishes and fresh water mussels. The more obvious and interesting facts of structure, development, habits and economic relations receive chief attention and their treatment is not technical but is thoroughly accurate, as would be expected by those acquainted with the high scientific attainments of the author.

The book is certain to be useful in our schools of the interior, for collateral reading in connection with zoology courses and in making the marine specimens of the school collection much more interesting.

F. S.

REPRINTS OF CUTS OF THE MOON.

If any of our readers desire reprints of the series of half-tones descriptive of the moon, published in this and the January numbers of SCHOOL SCIENCE AND MATHEMATICS, they will be supplied to all ordering by March 1, at one dollar per hundred.

PUBLISHERS' NOTICE.

The Chicago Clearing House has just put into effect a charge of 10 cents for collecting checks for less than ten dollars, and 15 cents for larger checks. If personal checks are sent, please add the amount for collection as indicated. Please remit by money order, express or postal, or by bank draft.